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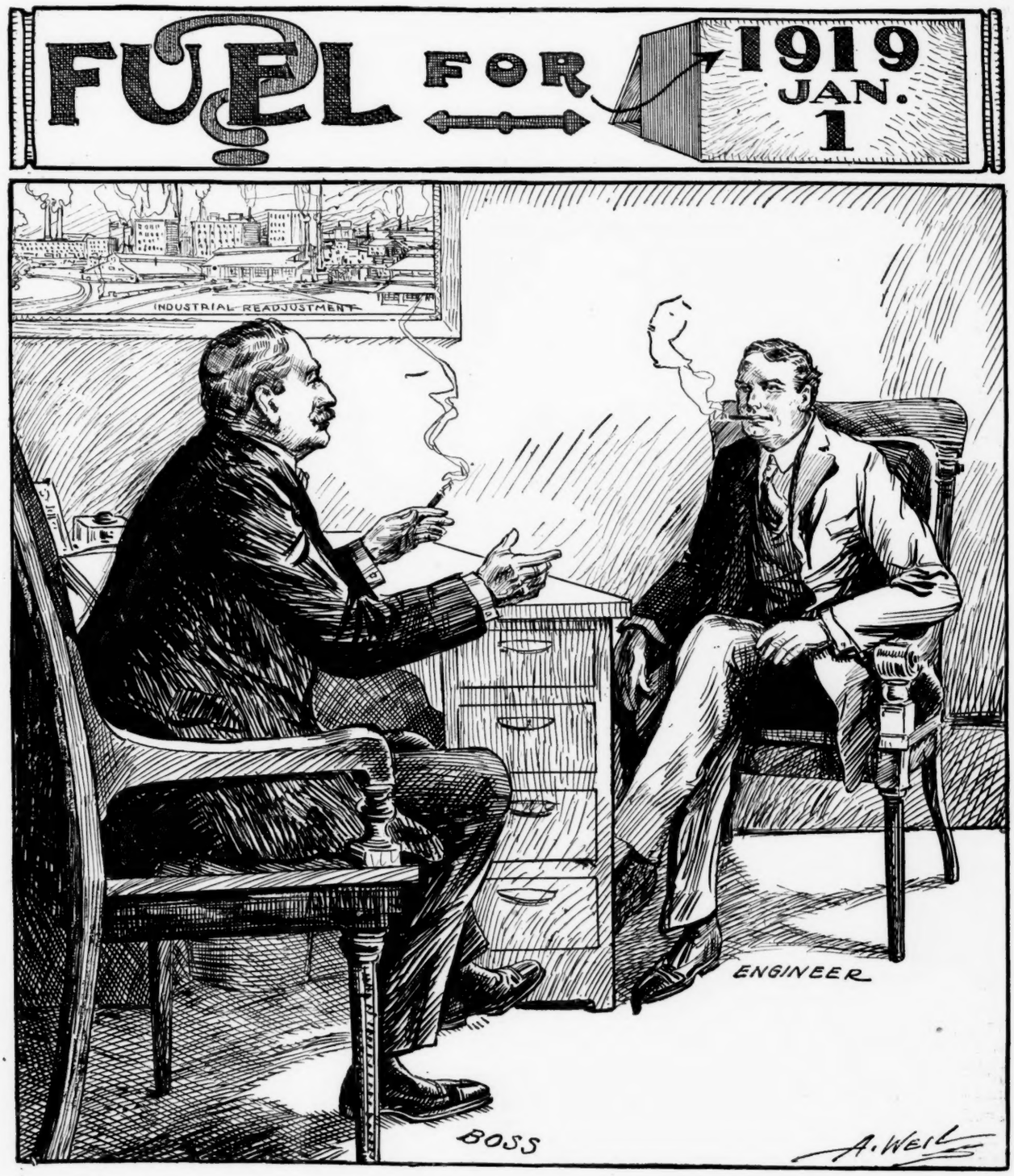


For the power plant this era of reconstruction is a period for reform. War times have revealed the economies that can be realized by stopping leaks and by better practice in the boiler room.

Review of the Year in the Power Field

WITH war work absorbing 90 per cent. of the energy of the mechanical industry and with the remaining 10 per cent. devoted to necessities, there has been no opportunity for pioneer work in the power-plant field, even if scarcity of materials, shortage of labor, excessive costs and overloaded transportation facilities had not prohibited effort in this direction. As a matter of fact experimental, inventive and development work has been practically suspended for the last two years, so that except for isolated cases where necessity has been there is little progress to report.

Fuel Conservation Efforts

There have been developments, however, originating as necessities imposed by the war, that are noteworthy and will leave their impression on the field.

Of primary importance are the fuel-conservation efforts made by the Government and the means employed to effect savings in the consumption of coal and oil. The power-plant questionnaire has brought results. An estimated saving of 3,500,000 tons is reported for the first six months. This is at the rate of 7,000,000 tons per year, and is only a beginning. In the plants that adopted the standard recommendations and kept systematic records there have been savings as high as 25 per cent. and the average is placed between 10 and 15 per cent. From statistics gathered from widely separated districts the "daylight" saving is estimated at 1,250,000 tons, the skip-stop plan is reported to have saved about the same amount, and the direct result of the entire industrial conservation program has been given an annual saving throughout the country of 25,000,000 tons of coal, without reducing the output of the factories. In some of the states work was slow in starting and there was some lapse of time before activities began in the individual plants. It is safe to say that the actual saving was only a small part of what it might have been if the work under the present organization had been continued for another year.

Owners Awakened to Possibilities of Efficient Operation

While under the strenuous war conditions existing for the greater part of the year even the relatively small saving made was gratifying, it is only an incident to the benefits that may be expected for the future. The mere fact that the power-plant owner has been awakened to the possibilities of efficient operation, that the engineer generally has been aroused from former routine performance and may expect coöperation from above, means much more than a temporary saving. The work done by the Government will continue to bear fruit in the years to come. Without considering the question of conservation, the owner, from the standpoint of personal gain, will not permit resumption of wasteful methods in the power plant. As for the engineer, his reputation is at stake. Normally conscientious, he will appreciate the coöperation that he has always solicited, and with the equipment and instruments necessary for economy, the progressive engineer will maintain and perhaps better the record set in the present emergency. The war has made evident the real meaning of efficiency, and not only in power-plant work but in all processes of production, manufacturing and distribution, it is to be the keynote in the reconstruction period now upon us.

Since the signing of the armistice there has been a decided slowing up in the activities of the United States Fuel Administration. Report has it that the work of the conservation department ends with the year, although regulation of distribution, particularly of domestic coal, will continue throughout the winter. The statistical division of the organization will hereafter be under the direction of the United States Geological Survey, and it is hoped that the work of conservation will be continued by the Bureau of Mines. As this procedure is in accord with the general trend of opinion in the field, it will meet with approval, particularly as it was feared momentarily that the information accumulated at so much expense in time and money would be lost. Although a new organization will have to be perfected, the work is in good hands and with proper Government support should be given the efficient attention for which the Bureau is noted.

Pooling of Power

As a part of the plan of conservation considerable attention was given to the consolidation of the services of adjacent plants where an economy might be effected by the more efficient plant supplying its less economical neighbor. Owing to the limited time available and to the fact that compulsion was not resorted to little was accomplished along this line. In the East and the far West because of the excessive demands for power and the need for reserve capacity, interconnection between large electrical systems was common. In the Southeast and the Central West it already existed.

Coöperation between Private Plant and Central Station

With the ostensible purpose of saving coal an active campaign to take over noncondensing isolated plants for the duration of the war was conducted generally by the central station. The movement was facilitated by the high price of fuel and the scarcity of competent firemen. A comparison was made between the three pounds of coal required by the central station to produce a kilowatt-hour at the switchboard and the six to ten pounds utilized in the noncondensing private plant. Evidently a large saving in coal was possible, but only on the basis of the electrical load. When combined with heating and other steam-using services, the question became more complicated and investigation developed that in the majority of cases there would be a loss instead of a gain by separating the services. In most plants, however, this argument does not apply to the nonheating period of the year. When no exhaust steam is required for heating or other purposes and there is no steam-using equipment other than the generating units, there is a decided advantage in purchasing summer current when it can be obtained at a reasonable rate. Summer load is also advantageous to the central station in utilizing equipment installed to carry the heavier winter load.

Continuous effort has been made to fill the summer valley, and some of the more progressive public utilities have begun to realize that this desirable condition might be attained by coöperation with the isolated plant. Discarding the old-time policy of "all or none" and concentrating their efforts on a plan that would be of mutual advantage has resulted in progress. In Chicago certain plants have adopted the foregoing plan with profit, although in others investigation revealed that no saving could be made. It is of course a question for individual analysis.

More Coal Stored Than Ever Before

Relative to the coal situation one of the difficulties was a shortage of labor in the mines. When war was declared two years ago, there were 700,000 miners. About 60,000 were lost in the draft and many more to other industries paying higher wages. Notwithstanding this loss in labor, there was a 10 per cent. increase in production the first year, and from statistics available at the time of writing a similar gain was made last year. A production of 700,000,000 tons of coal was anticipated and the actual output closely approximated this figure. To spread out the work of the miner and make it continuous the year around, there was a great call for storage. Coal users responded and it is safe to say that more coal was stored last year than ever before. With the so-called Western coals from Illinois, Indiana and other states, considerable trouble was experienced from fires, due largely to lack of knowledge of what to avoid, although literature giving explicit instructions had been widely distributed. It is gratifying to note that arrangements were made by the Fuel Administration to visit as many of these fires as possible to ascertain the cause and put them on record on photographic plates. These illustrations and the accompanying data are to be published at an early date, giving a wealth of valuable information for future guidance.

Relieving Railway Congestion

Another angle of the coal problem was the lack of transportation facilities. One suggestion to relieve the situation was the installation of pipe lines from the mines to the centers of distribution. The coal was to be pulverized and washed at the mines, mixed with water and pumped to its destination at an estimated cost ranging from twenty-five cents to one dollar per ton in extreme cases.

Generating current at the mines and distributing it by high-tension lines to points where electrical energy is required was a plan given impetus by the exigencies brought about by the war. Although in favorable localities a number of such plants already exist, it was proposed to divide the country into districts, each section to be served by large central stations at the sources of fuel supply.

In either plan there are certain advantages, but the initial investments would have been enormous and the time element involved would not have permitted the immediate relief required. The zone system for the distribution of bituminous coal was the final solution. It succeeded in relieving congestion by reducing the car mileage per ton of coal delivered. The facilities available were thus utilized to better advantage, and the railways were able to handle more coal. Temporarily, the plan did embarrass coal users where a change in fuel was enforced and the equipment at hand had not been designed properly to meet the new conditions. Modifications in the furnace and in the methods of operation were necessary, but when the proper adjustments had been made, the consumer had learned to burn an inferior coal and quite frequently at a reduction in the cost of operation.

Physical Progress Halted by the War

As to developments much that was said in the review of a year ago still applies. There has been a brief halt in the remarkable progress made in the last few years. During the short period of readjustment the engineer will transfer his work from war to peace. Taking advantage of the lessons of the past and the many new things learned under the stress of the world conflagration, coupled with the new spirit born of the war, demanding efficiency and coöperation, the opportunity for progress is boundless. If precedent is an indication, the advance in the next few years should eclipse all records of the past.

Notable Steam Power Plants

Although in the year just past the tendency has been toward makeshifts to get along with the equipment installed, due to Government priorities, long deliveries and excessive cost, and at the same time carry an increased load, a number of noteworthy plants have been placed in service. Some stations of enormous proportions have been built to serve munition works, but of these details are not available. At Windsor, W. Va., work has been continuing on a huge mouth-of-mine plant designed to deliver bulk energy to the surrounding industrial district. A capacity of 200,000 kw. in six units is planned. Of this two 30,000-kw. machines are in service, two more were expected to be ready before the close of the year and the final installation to be completed shortly after. A turbine is served by four cross-drum boilers, each having 12,625 sq.ft. of heating surface and equipped with a superheater, an individual economizer, induced draft and forced draft applied to an underfeed stoker. The operating pressure is 250 lb. and the superheat 250 deg., giving a steam temperature approximating 650 deg. Coal direct from the mine is received in a pit under a central firing aisle and is delivered to individual stoker hoppers of large capacity. Between each pair of turbines is a condenser pit 74 ft. deep, containing two horizontal condensers of the Leblanc straight downflow surface type. Each contains 50,000 sq.ft. of surface, or $1\frac{3}{4}$ sq.ft. per kilowatt of generator rating. Wide fluctuations in the river level made this construction desirable. The generating units were placed above the highest point which the river reaches and the condensers low enough to avoid lifting the cooling water at low stages. One of the unique features of the installation is a mercury expansion joint to take care of the vertical expansion in the condenser and the exhaust pipe from the turbine, which is 13 ft. diameter and 40 ft. long.

Following general practice in the steam end of large stations, the electrical connections have been arranged on the unit plan. A ring bus is employed. Each generator supplies its particular section of the bus and the corresponding feeders. Between each unit section is a bus reactance with a short-circuiting switch so interlocked

with the generator switch that it will close when the latter opens and cut out the reactance. Owing to this provision only one reactance can intervene between running generators and the voltage troubles that might ensue if the current from one section of the bus should pass through several reactances in series, are eliminated. This design and layout is original and it is believed to be the first of its kind.

Another bulk station distributing in quantity to substations has been made ready for service in Cincinnati. Two 25,000-kw. units are now in place, and there are plans for an eventual capacity of 200,000 kw. The design follows closely that at Windsor. The boiler-room arrangement is much the same, with the addition that natural-gas burners are installed in the rear wall of each boiler, so that gas or coal may alternate as fuel or the two may be used in conjunction. For the same reason as at Windsor the condensers and auxiliary equipment are located in pits, the condensers, however, being of the vertical rather than of the horizontal type. In the electrical end the same ring system of bus connection is employed.

A third plant that will have a probable total capacity of 200,000 kw. is under way in Kansas City. Here again the general design is similar to the two plants previously cited. There will be an innovation in the economizer, which is to be divided into a high-pressure element above and integral with the boiler and a low-pressure section of the usual design. Progress on this station has been delayed by the war.

At Wyandotte, Mich., the Pennsylvania Salt Manufacturing Co. has completed a modern alternating-current plant with rotary-converter transformation to direct current for electrolytic work. It is notable for the prominence given the boiler room, the profuse use of instruments and in the boiler room their convenient location on a central operating board also carrying the control for boiler auxiliaries and dampers. An unusual feature is the use of a series of eductor-type jet condensers in order that the steam auxiliaries may be operated under partial vacuum varied to maintain the heat balance. For the latter purpose electric drive of certain auxiliaries improves the flexibility.

A new station having all the modern requirements and intended for an ultimate capacity of 100,000 kw. is the plant erected recently at Miller's Ford to serve Dayton, Ohio. Two units aggregating one-quarter of the final capacity are now in operation.

Muscle Shoals Nitrate Plant

Perhaps from many angles the most interesting plant to be erected during the year is No. 2 plant of the Air Nitrates Corporation at Muscle Shoals, Ala. The installation is one of the largest made as an initial installation, and its output per year will likely be larger than that of any other plant, if not of any other system. The plant load factor will be 90 to 93 per cent.! This plant, or rather the conditions for which it was designed, are certainly the closest approach to the ideal that engineers have yet encountered. A description of the many interesting engineering features of this steam station is now in preparation by one of the *Power* staff and will cover several articles soon to be published.

In Milwaukee some interesting experiments relative to the use of powdered coal in a central station have been conducted on an initial equipment serving a 468-hp. water-tube boiler. A net efficiency of 81 per cent. is reported, and the general operation proved so satisfactory that four more boilers of the same size are being similarly equipped. Apparently the installation has made a record as far as the use of powdered coal in the power plant is concerned. Burning inferior coal at high efficiency is a question of vital importance in the cost of operation. The system installed has this advantage coupled with ease of control, flexibility, uniformity and low draft requirements. In the past troubles from slag and fine ash and the high initial cost of the equipment have been the bugbears in the way of progress. At Milwaukee the slag difficulties have been eliminated. When results are available from the completed plant, data on the other two factors will be received with interest.

Things of interest have been developing relative to the utilization of anthracite culm by the powdered process. There are many reasons why this fuel may be efficiently burned in pulverized form in furnaces designed for burning it in this form. Engineers should soon solve the culm problem, for there are millions of tons of it above ground. It is too soon at this writing to go into particulars as to what has been done in the way of studies and development; but soon we will be in a position to publish some interesting information.

The Steam Turbine and Auxiliaries

Before this country entered the war there had been a decided movement toward higher pressures and superheats to increase the temperature range of the steam and thereby improve the economy of the plant. With the steam turbine a considerable gain is possible. The physical limit of standard equipment, particularly in the boiler room, is 700 deg. and more likely below that figure. What proportion of this final temperature shall be due to pressure and what to superheat is the immediate question at issue. At first glance higher pressures offer greater opportunity for gain, but with the present designs of boiler, the increase is limited and there is need of superheat to keep down the moisture and the resulting windage and friction losses in the turbine. The tendency then is toward higher pressures with sufficient superheat to minimize condensation and the problem is to perfect boilers and turbines for pressures of 500 lb. A number of the larger plants now operate with initial temperatures of 650 to 700 deg. However, the success of such high temperatures is questioned by many competent engineers.

Bearing close relation to the foregoing question is the design of a turbine that will give safely the best results with the lowest initial investment. Limit in size in a single cylinder and peripheral velocities in the lower stages are also phases of the problem demandng attention.

During last year an unusual number of large turbines were placed in service, and the experience in operation obtained will help point the way. The most noteworthy in size at least, are the two triple-cylinder compound units, one now operating in the Seventy-Fourth Street Station of the Interborough Rapid Transit Co., New York City, the other nearly ready to operate in the plant of the Air Nitrates Corporation at Muscle Shoals, Ala. Both are of 60,000 kw. normal rating, 70,000 kw. maximum. The water rates and flexibility of these

units are interesting, and we hope to treat fully of these in the articles dealing with the Muscle Shoals plant. The 60,000-kw. unit in the plant of the Duquesne Light Co. is also a noteworthy installation. Others are the 45,000-kw. cross-compound reaction turbine for the Narragansett Electric Lighting Co., of Providence, the Detroit Edison and the Public Service Electric Company's single-cylinder impulse machines each of equal capacity. With the enormous increase of capacity in impulse turbines of the single-cylinder, single-flow type, difficulties have developed in operation and as a result there has been an unfortunate chain of accidents on large machines of this type. But it should be borne in mind that war conditions have made it difficult to get uniform materials with which to build these machines, and that, as everywhere, labor conditions have not been conducive to the best workmanship. These are troubles of the moment, and, as we have frequently stated, the profession should be tolerant of these occurrences in the development of a truly remarkable type of prime mover. Comparing favorably in economy with other types, the machine has the advantage of simplicity, small weight and a price that could be correspondingly low. These features lie back of the design.

The Trend of Turbine Capacities Is Still Upward

As to limits of capacity in turbine units, the evidence shows that the trend may continue upward rather than downward, and with success. To say that 20,000 kw. is the safe and economical limit, without qualification, is to ignore what has already been achieved.

As with other equipment, advance in condenser design has been nominal. Practically, the full output of surface-condenser manufacturers has been needed by the Government for marine installations. The necessity for conserving copper brought forth the suggestion that beginning with the present year steel tubes be placed in condensers for land uses. Expansion would be reduced by the use of steel, but it was recognized that the heat transfer through steel tubes would be considerably less than with muntz metal and that corrosion would present a serious difficulty. The signing of the armistice relieved the situation to some extent, and it is doubtful whether steel tubes will be given further consideration. Where feasible, jet condensers were installed, but there were few land plants fortunate enough to obtain condensers of any type.

In the removal of air from condensing equipment there has been a marked tendency toward the use of ejector-type apparatus, steam or water being used as the propelling medium. Light weight, lack of moving parts, small space occupied and simplicity of operation are the advantages enumerated in favor of this equipment. Development work has been going on for several years and a perfected product is now available. As a reference to apparatus of this type, mention should be made of the Worthington hydraulic air pump, the Leblanc "Multijector," the Wheeler "Radojet" and the air occluder of the Alberger Company.

Supplying boilers for ships, for war plants and for more ships, sums up the activities of the year. Quantity production and limitations on steel eliminated all pioneer work. Two years ago forced draft for chain grates was an early possibility. Experimental work, however, had to be discontinued, and the matter stands in abeyance, although developments may be expected in the year now under way.

In engineering relating to shipping a noteworthy work has been done by the United States Shipping Board Emergency Fleet Corporation. The importance of having uniform, reliable machinery aboard the enormous tonnage called for by the Board's program is obvious. A measure that will accomplish this is the standardization of all this machinery by committees including about seventy of the leading engineers of the country. The work was under the direction of John A. Stevens, as Standardization Engineer, who is well-known as chairman of the Boiler Code Committee of the American Society of Mechanical Engineers. The Boiler Code was about eleven years in the making; considering that the ship machinery standardization was completed in a matter of weeks, the dispatch of this really noteworthy work is apparent.

The zone system of distribution has focused more attention on the furnace. In those plants where a transfer had to be made from Eastern to Middle West coal, it was almost invariably the rule that the furnace volume was too small to care for the excessive volatile content and there were difficulties in removing the greater quantity of ash. Even in furnaces designed for the poorer coals of the Middle West, it was found that results could be improved by enlarging the furnace and increasing ignition by the use of more refractory material in arch and bridge-wall. For Iowa and Colorado coals volumes as high as 12 cu.ft. per square foot of grate area are no longer considered excessive. This may be compared to 6 cu.ft. as a previous standard and to volumes considerably less for coals from Indiana and Illinois.

Progress in Burning Lignites

Necessity has also enforced considerable progress in the burning of lignites. Experience has shown that lignite can be burned under boiler furnaces without insurmountable difficulties, and the Bureau of Mines is sponsor for some excellent work showing how it may be done. A summary of the suggestions advanced may be obtained in an article by Henry Kreisinger, appearing in the Apr. 30 issue of *Power*. Even in peace times it is in the interest of national economics to eliminate the long hauls and the attending expense common in the coal trade. Industries adjacent to the lignite fields should investigate the possibilities. When stokers, furnaces and methods have been adapted to this fuel, a reduction in operating expense is more than probable and transportation will be relieved of an unnecessary burden. To provide furnaces and stokers of proper design is up to the manufacturer. Some already have information to supplement the work of the Bureau, so that rapid progress may be expected.

While no specific information is available for publication at this time, the year has witnessed much thought devoted to the problem of extracting the many chemicals from the volatile matter in coal before its use in boiler furnaces. Here is an interesting field and one pregnant with great possibilities because the heat value of coal will be decreased but little by the extraction of the volatile content. We are of the opinion that it will be inadvisable to entirely remove the volatile, for then combustion difficulties would likely arise.

Interesting experiments are to be carried out to ascertain the value of methane, or the gas commonly known as firedamp, as a fuel. There are millions of cubic feet of methane drawn from coal mines by the ventilating fans and this gas has been discharged to the atmosphere for years without any attempt being made to ascertain if it is adaptable for use in boiler furnaces as an aid to combustion. At the Loomis colliery of the Delaware, Lackawanna & Western Co., an experimental station has been erected for the purpose of determining the value of methane in mine air by introducing it into a boiler furnace, instead of taking air from the atmosphere. A comparison of results obtained by using methane air in the boiler furnace and that from the atmosphere will give the value of using mine air. Another problem to be solved is whether the return air from the mine containing 1 per cent. of methane and less oxygen than pure air can produce greater heat from the coal consumed than can be obtained with pure air. The results of the Loomis experiments to be obtained are problematic, but they will be highly interesting to mine-plant engineers.

Water-Power Developments

Owing to the shortage of coal and the excessive demand for power, special efforts were made to speed up action in the House of Representatives on the passage of water-power legislation. Very early in the year President Wilson turned over to this body a new water-power bill, known as the Administration Bill, in which attempts had been made to coördinate water-power legislation proposed for several years past in both Houses of Congress, not only on the public domain, but in navigable streams as well. The bill provided for a water-power commission to be composed of three Cabinet officers and for an executive officer of the commission to be appointed by the President for five years. A House committee of eighteen was appointed to compose differences as to the various bills that had been under consideration and facilitate if possible the passage of the new bill. Altogether this bill appeared to be a great improvement over former attempts, although it was not without objection. Repeated hearings of the special joint committee resulted in many changes in the original draft of the bill, three entirely new sections and several practically rewritten. It was eventually licked into shape for action by Congress, but the bill got no further and is still up for passage.

During the year hydraulic power already installed was utilized to the fullest extent, and the plans for interconnection were carried out where feasible. At Niagara it was proposed to consolidate the three large power companies and by an expenditure of $15,000,000 erect an additional plant that would increase the output by 170,000 hp. The request came from the War Department as a necessary war measure to provide sufficient power for war industries in and about Buffalo. There were many other plans for interconnection, including the erection of enormous stations as links in the chain, but the early ending of the war made the carrying out unnecessary at least for the time being. In California all systems are now tied together for exchange of power. In the Southeast they were already connected in this way. Systems under different management in Washington and Idaho have also been linked together. In Montana eight hydro-electric plants are successively using the same stream flow. Not only the natural flow but the storage water as well is effectively utilized by each plant. In this system the annual load factor is 75 per cent. and the mean monthly load factor, 80 per cent. It is evident that interconnection of hydro-electric plants makes for greater effective use of variation in rainfall, as different watersheds are thereby brought to serve a common system. The statement has been advanced by E. W. Rice, Jr., that the useful output of groups of large systems may through interconnection be increased 25 per cent. This was made possible by the saving in reserve equipment, improvement in load factor and the diversity of the different loads.

An incident of the year was the turning over for the first time of the 25,000-hp. Francis turbine in the White River generating station of the Puget Sound Traction, Light and Power Company. It is the most powerful high-head (440-ft.) turbine of its type in the world and is practically a duplicate of the two 18,000-hp. machines placed in commercial operation in the same plant in 1911. Fifty per cent. of the additional power will be supplied to the Coast Division of the Chicago, Milwaukee & St. Paul Railway. It will be delivered at 100,000 volts and be converted into direct current of 3000 volts for use in the motors of the electric locomotives.

The enormous water power available from the Tennessee River is now, perhaps, nearer actual development than it has ever been. Its development will certainly open up a region in the South where industrial possibilities will be exceptionally favorable because of the cheap power, and the resources in raw materials. The country is justified in expecting the development of this water power without delay.

The Electrical Field

Last year and in fact for several years there has been no material improvement in the efficiency of electrical units such as generators, motors and transformers. Efforts to increase the economy have been transferred from the unit to the system, where maximum use of generating and distributing equipment is the all-important problem, calling for intensive study of load factors of generators, stations and the systems as a whole and careful consideration of the diversity factor. Reduction of constant and no-load losses and the use of synchronous equipment to reduce the idle currents also enter into the problem. As a result of study along these lines automatic substations are being installed, stations of a system are being tied together and transmission lines of different systems are being interconnected as previously indicated in the section under water power. There has been marked improvement in over-all efficiency, but there are still plenty of opportunities for further gain.

There has been decided progress in electrical furnaces. In the last year the number employed has practically doubled, and there are over five times the number that existed five years ago. War demands have, of course, been partly responsible, although with the electric furnace it is now possible to produce steel at a cost comparing favorably with openhearth production, and obtain a better product, due to the exact and easy regulation

that is possible. Single-phase furnaces are losing prestige to the three-phase type, by reason of the more desirable load characteristics of the latter.

A More Sturdy Tungsten Lamp

A product of the year is a new tungsten lamp more sturdy than the present design. From a steel supporting rod the filament is braced at four different points. As a consequence it is not nearly so fragile as the present tungsten and full advantage can be taken of the high efficiency offered by this type of lamp without undue breakage. It is a product of the committee on war service of the Illuminating Engineering Society and is considered one of the best things that it has accomplished.

Scarcity of copper and steel set engineers to thinking of substitutes: for example, steel tubes for condensers and reinforced concrete for steel beams and columns in the power plant. A case in point is the new 15,000-kw. Buffington, Ind., power plant of the Universal Portland Cement Company.

On the electric light and power industry war effects were heavy increases in operating costs and excessive prices for plant equipment to take care of the rapidly increasing demand. For 1918 the output of central stations was nearly 75 per cent. greater than in 1914. The price of coal has practically doubled, and the average advance in labor is at least 25 per cent., this to be coupled with scarcity of men competent to maintain high standards of efficiency. Over the pre-war level, prices of hydraulic machinery are reported to have advanced from 100 to 150 per cent.; electrical apparatus, from 125 to 150 per cent.; steam-turbine generators, 150 per cent., and water-tube boilers, 170 per cent., with uncertain and in most cases long delayed deliveries.

To help carry the increased load, interconnection and pooling to a limited extent have helped. During the year for the most part it has been necessary to get along with the equipment on hand, using it to the maximum, and as might be expected in times of stress, suffering an unusual number of accidents. There have been many boiler explosions, economizers have let go, turbines and flywheels have been wrecked and even generators have exploded. A recent case of the type of accident last named was the generator wreck in the St. Paul plant of the Northern States Power Company; the generator was, however, of a type long ago abandoned by the builder.

The Engineer in a New Role

The engineering profession is coming into its own. The war has done much to change the attitude of the engineer toward affairs of state and the public welfare generally, and of equal importance, the public is beginning to realize the true importance of the engineer and his relation to public work. It has been an engineer's war from start to finish. The Government early realized this and has called continuously for assistance and advice. Even in matters of legislation the Government has asked for guidance. In the old days such procedure was unheard of, and the engineer, with an aversion to publicity, even of the most reserved character, was apparently content to allow the lawyer and the politician to take his place in the sun. As previously intimated, the war has changed all this. As a duty to the public and to his own profession the engineer has at last come to realize that in addition to the actual doing of engineering work, he must guide legislation, relating to his field, along proper channels, and that publicity, giving credit for engineering accomplishment where credit is due, is the thing needed to raise the profession in the eyes of the public. Through the coördination of the great engineering societies of the country to more effectively serve the Government, the engineer has also learned the value of coöperative effort. It is an excellent introduction to the new rôle the engineer is destined and so well qualified to assume in the future. In this development engineering education will have an important bearing, and in this connection the studies along this line of Dr. Charles R. Mann under the joint auspices of the Carnegie Foundation for the Advancement of Teaching and the Joint Committee on Engineering Education of the national engineering societies, is worthy of the most serious consideration.

It is gratifying to record the additional $100,000 donated the Engineering Foundation for endowment of engineering research by Ambrose Swasey, of Cleveland. In 1915 he gave $200,000 for this purpose, so that his gifts now total $300,000.

To meet the new need for an agency to aid engineers who have been in military service to find suitable positions, the Engineering Council has established an Engineering Societies Employment Bureau, with headquarters in the Engineering Societies Building, New York. It is to continue the excellent work that the American Engineering Service rendered the Government during the war. The movement is an indication of the trend toward helping the young engineer by taking a paternal interest in his welfare in addition to offering him the advantages of education and association that membership previously held.

Power-Plant Legislation

In legislation pertinent to the field, some modifications in boiler rules relative to safety of construction and operation have been made to meet temporary war conditions. No additional state license laws have been passed. The emergency power act was a notable bill recently passed. The provisions conferred vast power upon the President, authorizing him to provide sufficient power for war work by taking control of existing plants or adding to their capacity, by building new plants, by consolidating power systems or by diverting power from one industry to another. It was a war measure warranted by the conditions at the time of its passage. The early signing of the armistice made enforcement unnecessary.

The Honor Roll for 1918

First place goes to the engineers who made the supreme sacrifice for their country. Those who came back will receive the honor due them as will the men who stayed at home and gave their best efforts in backing up the troops at the front. Mention should be made of the award of the eighth Edison Medal to Dr. John J. Carty, colonel in the United States Army Signal Corps and chief engineer of the American Telephone and Telegraph Co. The recognition was due to meritorious achievements in the science and art of telephone engineering. Other scientists previously honored in the same way were Elihu Thomson, Frank J. Sprague,

George Westinghouse, William Stanley, Charles F. Brush, Alexander Graham Bell and Nikola Tesla. Engineering societies closely related to the field honored the following men with the presidencies of their respective societies: Mortimer Elwyn Cooley, American Society of Mechanical Engineers; Comfort A. Adams, American Institute of Electrical Engineers; W. F. Wells, National Electric Light Association; Roderick Mackay, National Association of Stationary Engineers; George E. Wells, American Society of Refrigerating Engineers; Fred R. Still, American Society of Heating and Ventilating Engineers; Charles F. Rand, United Engineering Society; J. Parke Channing, Engineering Council.

Necrology

A number of men of prominence in the field passed away during the year. The columns of *Power* record the following: Christopher W. Levalley, founder and chairman of the board of directors of the Chain Belt Co.; F. G. Rollins, late president of the Holmes Metallic Packing Co.; Adam Cook, senior member of the firm of Adam Cook's Sons; John P. Sparrow, chief engineer of the New York Edison Co.; Charles Jenkins, at one time member of the firm of Jenkins Bros.; E. C. Meier, president of the Heine Safety Boiler Co.; Frederic Remsen Hutton, well-known engineer educator and distinguished member of the American Society of Mechanical Engineers; Frank J. Corbett, vice-president and secretary of the Bergen & Linderman Co.; Charles Allis, second son of the late Edward P. Allis; George William Dickie, naval architect and marine engineer; William Kent, eminent engineer and author of many technical books; William Allis, at one time chairman of the board of directors of the Allis-Chalmers Manufacturing Co.; Lieut. Charles R. Seed, superintendent of power of the Worcester Electric Light Co.; Charles F. Simms, for many years manager of the Omaha office of H. W. Johns-Manville Co.; Martin W. Kern, mechanical engineer of the Narragansett Electric Lighting Co.; Edward Allan Wickes, president of the Niagara Falls Power Company.

Thermometer as a Boiler Blowoff Indicator and Tank Counter

By George W. Caywood

Some time ago there was published in *Power* a description of an apparatus consisting of a check valve located in the blowoff pipe and connected to a clock-operated chart to indicate when the boilers were blown down. (See page 744, Nov. 28, 1916.) Since then other devices, more or less complicated, have been described.

At the steam plant of the Minneapolis Street Railway Co. we have found that a recording thermometer is valuable for this purpose. All blowoff pipes are connected to one 6-in. main. The thermometer bulb is placed in this pipe, inside a short nipple, to protect it from damage by the rapid passage of scale or other matter when blowing down. We have also found it valuable as an indicator of the condition of the blowoff valves.

The chart, Fig. 1, shows the temperature of the blowoff pipe at normal condition; it also shows at what time the boilers were blown down and that the recording pen returned to its normal position, indicating that all valves were closed tight. Should a bad leak develop, the chart would show an increased temperature. In fact this did occur and it was found that the blowoff valve on No. 15 boiler was leaking.

For boiler-test work a horizontal cylindrical tank is utilized to measure the water used. About midway in the vertical height is placed a standard mercury thermometer, also the bulb of a recording thermometer. On this we use a chart making one revolution in twelve hours, as a fast-moving chart results in a plainer diagram. This is especially desirable when high-capacity tests are run. This chart indicates each time the tank is filled and emptied and also shows the temperature of the water. The chart, Fig. 2, shows that the test began at 8:50 a.m. and ended at 4:51 p.m., and that 68 tanks of water was used. We do not depend on this alone for our records, but it is an excellent check on the men whose duty it is to keep a record of the temperature and the amount of water used.

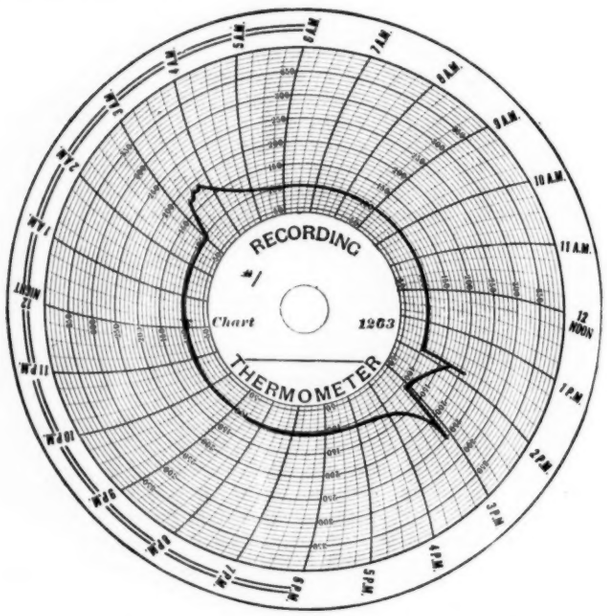


FIG. 1. BLOW-OFF TEMPERATURE CHART

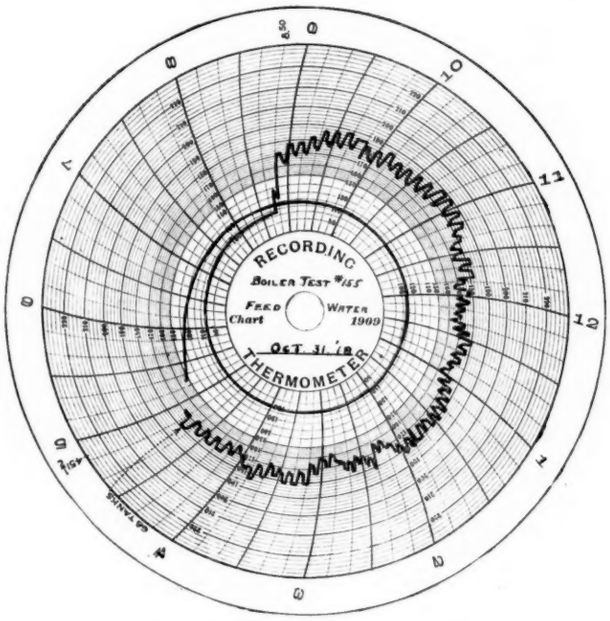


FIG. 2. TANK-FILLING CHART

Properties of Liberty Fuel and Results of Economy Tests

FURTHER particulars as to the nature and characteristics of the new Liberty fuel invented by Captain Weisgerber are now available. As stated in the Dec. 17, 1918, issue of *Power*, kerosene is the base of the new fuel. It is treated with a chemical, with the result that its oxygen content is increased, so that when the fuel is vaporized and admitted to the engine cylinder there is present some of the oxygen needed for the process of combustion.

The quality of Liberty fuel is under close control during the manufacturing process and may be regulated at will. The curves given in Fig. 1 show the relation between the temperature and the percentage of the sample driven over, during distillation tests of three different qualities of fuel, designated as *A*, *B*, and *C*.

Liberty fuel has a variable specific gravity according to its varying quality. The gravity may run from as low as 35 deg. Baumé to as high as 72 deg. Baumé. The heat value per gallon is 127,900 B.t.u. as compared with 119,200 B.t.u. for commercial gasoline and 112,300 B.t.u. for export gasoline.

Tests were made on a 150-hp. Hispano-Suiza engine to determine the relative performances of Liberty fuel and export gasoline. The results of these tests are indicated graphically by the curves in Fig. 2. It will be observed that Liberty fuel gives a higher thermal efficiency and a greater brake mean effective pressure than export gasoline. A greater weight but a smaller volume of the new fuel is required than of export gasoline to produce one horsepower-hour, the explanation being that the Liberty fuel weighs more per gallon than gasoline, in the ratio of about 7 to 5.9.

The chemical treatment to which the basic kerosene is subjected apparently transforms the heavier hydrocarbons into lighter ones, thus rendering the fuel easier to vaporize in the carbureter. As it carries with it some of the oxygen required for combustion the flame propagation is more rapid, resulting in a greater explosive effect.

According to the inventor, the temperature of the exhaust gases is about 140 deg. C. lower for Liberty fuel than for ordinary gasoline. This may be explained on the ground that the initial pressure is higher, the combustion period shorter and the exhaust temperature therefore lower; or, the presence of oxygen in the fuel enables a leaner mixture to be used, which would tend toward cooler running conditions.

The first Liberty fuel was made in small glass retorts in a laboratory. Later, when larger quantities were desired, it was necessary to procure a large still; but the largest that could be obtained was a 3-gal. gin still. Liberty fuel has been compounded for tests in a large number of different makes of motor cars and, according to the inventor, has shown from 10 to 62 per cent. increase of mileage over gasoline. It has also been tried out in airplane and tractor motors with entire success. This fuel was developed in order to take care of the anticipated shortage of gasoline during the spring of 1919, with the idea of rendering kerosene available for internal-combustion engines of all types. The claim is made that the cost of the kerosene plus the cost of the chemicals and the expense of treating will amount to a little less than the cost of gasoline, though not materially less.

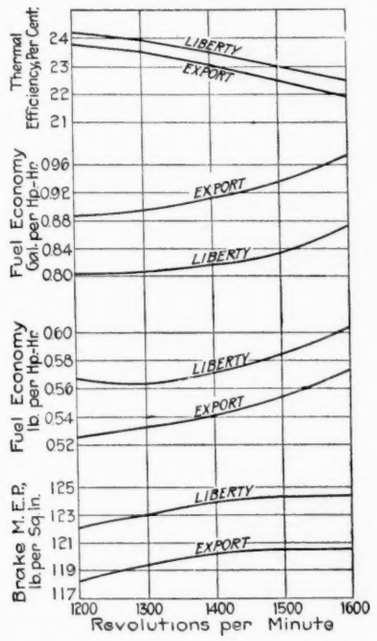


FIG. 2. RELATIVE ECONOMY OF LIBERTY FUEL AND EXPORT GASOLINE

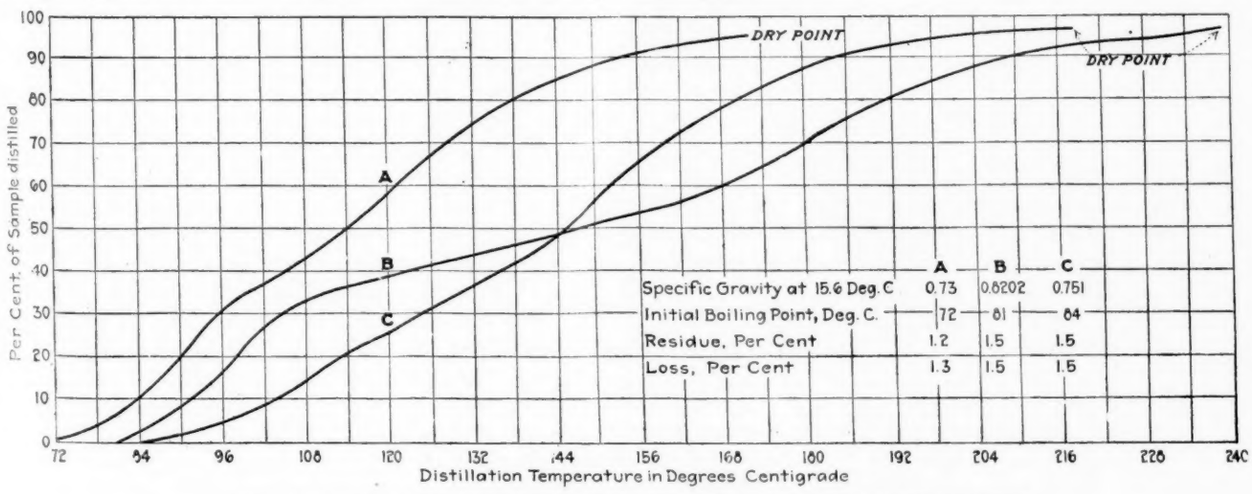


FIG. 1. DISTILLATION CURVES OF DIFFERENT GRADES OF LIBERTY FUEL

Reconnecting Induction Motors—For Change in the Number of Poles—III

By A. M. DUDLEY
Designing Engineer, Westinghouse Electric and Manufacturing Company

Reconnecting for changes in poles. The effect on the shape of the magnetic field of changing the throw of the coil and how reconnecting a given winding for different numbers of poles has the same effect as changing the throw of the coil.

IN THE article published in the issue of *Power* for Apr. 9, 1918, it was shown that it is possible to reconnect a given stator winding for different numbers of poles or speeds, and the method of determining the proper operating voltage for each such speed was explained. In the issue of Aug. 20 there was shown a method of plotting a physical representation of the rotating magnetic field as it varies from point to point around the air gap of an actual machine. It is the purpose of this article to show how reconnections of the stator windings affect the shape of the magnetic field and at the same time to show what effect is produced on its shape by changing the throw of the coil, or chording the winding as it is called. The latter effect will be investigated for a change of one slot at a time from full pitch to less than half pitch. By full pitch is meant that the span of the coil is exactly the same distance as that from the center of a north pole to the center of an adjoining south pole, and by half pitch that the coil spans or throws only half that distance. Referring to Figs. 9 and 10 of the article of Aug. 20 the small "stair step" figures represent cross-sections of the magnetic field existing in the motor as the alternating currents in the windings vary in value from instant to instant, and a comparison of the small figures shows that the magnetic field actually travels around the stator bore or "air gap" at a uniform rate. The number of revolutions that it makes in one minute is equal to 120 times the number of cycles per second of the supply circuit divided by the number of poles in the stator. Expressed in symbols this would be $S = 120 \frac{f}{p}$; where S is the speed of rotation in r.p.m., f is the frequency in cycles per second, and p is the number of poles.

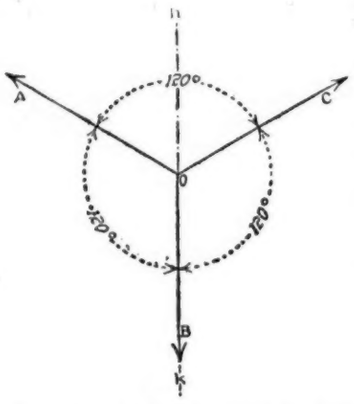


FIG. 1. VECTOR REPRESENTATION OF THE CURRENTS IN A BALANCED THREE-PHASE SYSTEM

In order to make clear the field photographs or diagrams of the present article and to obviate the possibility of confusion regarding them, attention is called to the fact that they represent the conditions existing in the windings at an instant of time when the current in one of them is at its maximum value. Since we are dealing with three-phase motors, the currents in the windings connected to the other two phases will at that instant both be equal to one-half their maximum values. This may be explained by reference to Figs. 9 and 10 of the article of Aug. 20, which represent the values of the currents in the three phases for every 30 deg. of a complete cycle of 360 degrees. Suppose these three currents are represented by the three branches, *A*, *B* and *C* of the "Y" illustrated in Fig. 1, each of which is 120 deg. from the other, and that a vertical reference line *hk* is drawn through the center *o*. Now assume that the "Y" rotates in a counterclockwise direction about this center while the line *hk* remains stationary, and that the three branches assume the successive positions represented in the second column of Table I. The values of the currents at any instant of time will be represented by the length of their horizontal projections upon the line *hk*. If the maximum value of each current is assumed to be one ampere, the instantaneous values of the three for each 30 deg. of a complete cycle would be those given in the last three columns of Table I. Projections that lie above the center *o* are taken to be positive and those that lie below as being negative.

TABLE I. INSTANTANEOUS VALUES OF THE CURRENTS IN A BALANCED THREE-PHASE SYSTEM AT INTERVALS OF 30 DEG. DURING A COMPLETE CYCLE, BASED ON A MAXIMUM VALUE OF 1 AMP.

ANGLE, DEG.	POSITION OF BRANCHES OF Y	CURRENT A AMPERES	CURRENT B AMPERES	CURRENT C AMPERES
0	0° B, C, A	-0.5	+1.0	-0.5
30	30° B, C, A	0	+0.866	-0.866
60	60° B, C, A	+0.5	+0.5	-1.0
90	90° B, C, A	+0.866	0	-0.866
120	120° B, C, A	+1.0	-0.5	-0.5
150	150° B, C, A	+0.866	-0.866	0
180	180° B, C, A	+0.5	-1.0	+0.5
210	210° B, C, A	0	-0.866	+0.866
240	240° B, C, A	-0.5	-0.5	+1.0
270	270° B, C, A	-0.866	0	+0.866
300	300° B, C, A	-1.0	+0.5	+0.5
330	330° B, C, A	-0.866	+0.866	0
360	Same as 0 Deg.			

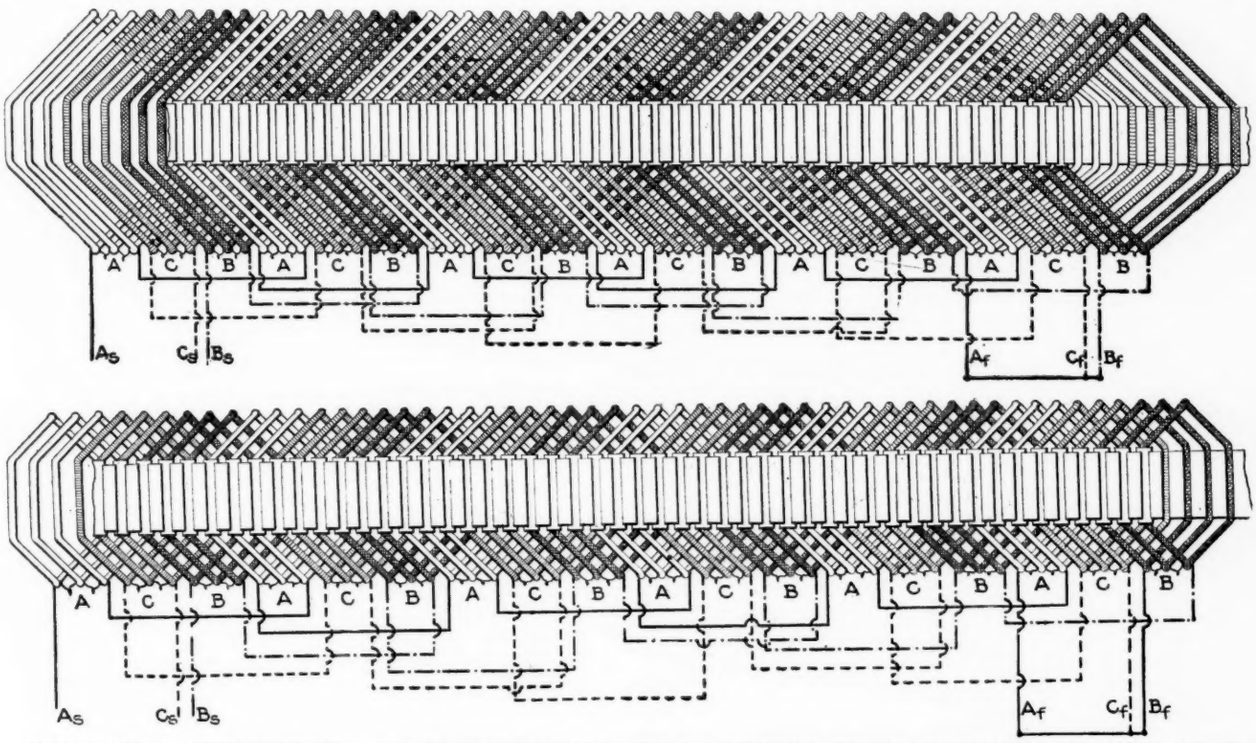
In the previous article there was given a picture of the field corresponding to each instantaneous value of the currents, but in the present article the figures are given for only one of these values and they have been chosen to be the ones existing when the condition is that shown for 0 deg. in Table I; that is, for the instant when the current in the *B* phase is at its plus maximum value and the currents in the *A* and *C* phases are at minus one-half their maximum values. Of course, any other position could have been chosen for conducting the investigation, but the values for the 0 deg. position are convenient ones to use when plotting the results.

Since one of the effects of reconnecting for a different number of poles is to affect the "chord" or throw of the coil, let us consider first the effect of "chording." A reference to the article on "Fractional Pitch Windings" in the issue of July 31, 1917, will be helpful in understanding the figures which immediately follow. Figs. 4 to 9 inclusive show the magnetic field constructed, as explained in August article, for a 54-slot three-phase 6-pole winding when the throw of the coil is changed one slot at a time from slots 1 and 10, as in Fig. 2, which is full pitch or 180 deg., down to slots 1 and 5, as in Fig. 3, which is less than half pitch; or to be precise, 80 deg. The same magnetizing current is assumed to flow in the coils in all six cases, although in an actual machine this would not be the case; the magnetizing current would increase with decreased throw of coil due to the attempt of the motor to keep the angle spanned by the coil. This relation is shown in the following table:

TABLE II. CHORD FACTORS FOR VARIOUS ANGLES

Figure	Angle Spanned by Coil = a Deg.	Sine ½a, or Chord Factor	Area of Magnetic Pole Figured from Chord Factor	Area of Magnetic Pole Graphically from Figure
4	180	1.000	32.0	32
5	160	0.985	31.5	31
6	140	0.940	30.1	30
7	120	0.866	27.7	27
8	100	0.766	24.5	24
9	80	0..642	20.5	20

The slight difference between the last two columns in the table is due to the area under the "stair step" curve not being quite the same as the area under the corresponding smooth sine curve. The chord factor as shown in the third column at once indicates two facts: First, that if the winding is chorded more current will



FIGS. 2 AND 3. WINDINGS OF A 54-SLOT THREE-PHASE 6-POLE INDUCTION MOTOR CONNECTED FOR FULL OR 180 DEG. PITCH AND FOR 80 DEG. PITCH

A_s, B_s and C_s indicate the start and A_f, B_f and C_f the finish of the windings for the three phases

field at the constant value necessary for the generation of the required back or counter-electromotive force. To facilitate comparison, however, this change in current has been disregarded in the figures. The "stair steps" show the magnetic fields as they would look if there were no winding on the rotor, and the smooth curves, having the sine shape, show the fields as they look after being smoothed out by the currents in the rotor winding. It will be noticed that the area of the field for one pole is given in each case and that it varies from 32 for full pitch in Fig. 4, down to 20 in Fig. 9. These areas correspond to what is known as the "chord factor" of the winding. In the article on fractional pitch it was stated that the chord factor for a chorded winding could be expressed in its effect on the magnetizing or no-load current and in its effect on the generated or counter-electromotive force by the mathematical value of the sine of one-half the electrical have to flow in the windings to produce the same magnetic field strength; and second, that since the generated or counter-electromotive force in the windings set up by the rotating magnetic field is reduced through chording by the amount indicated by the chord factor, it is necessary to have a stronger magnetic field in the motor if it is to operate at the same voltage when the coil is chorded up. The way this shows up in reconnecting for different numbers of poles, when the reconnection causes chording of the coil, is that the same effect is produced as would be if the motor were connected to a higher voltage. This will be explained fully in a later article dealing with the practical application of the principles presented in this series to the actual work of reconnecting.

An examination of the shape of the magnetic field indicates that the effect of chording is to flatten the top of the field and make it lower for the same pole

span. In Fig. 10 is shown the effect of connecting the winding of Figs. 2 and 4 for four poles instead of six. The mechanical throw of the coils is still 1 and 10, but the pole arc is longer for four poles, hence, the coil is actually chorded to 120 electrical degrees for

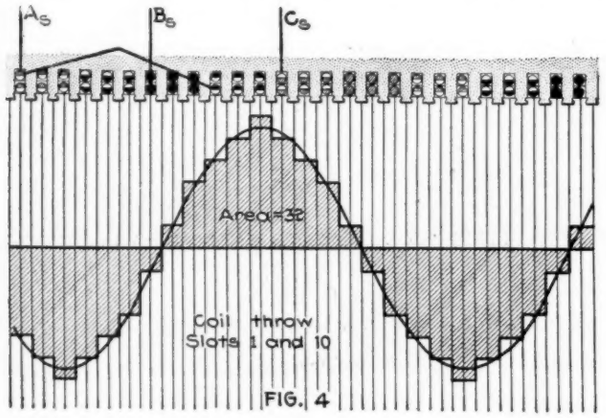


FIG. 4

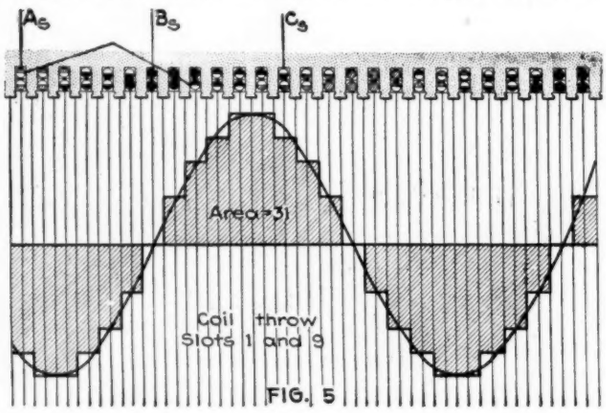


FIG. 5

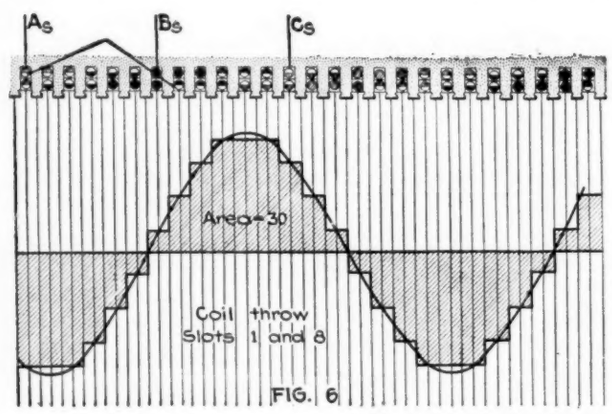


FIG. 6

(a) ● = + 1.0 Ampere, Phase B
(b) ◓ = + 0.5 " " A
(c) ◒ = + 0.5 " " C

with the same magnetic field density in the air gap and the same currents in the windings, the horsepower when connected as a 4-pole machine should be 1.5 times that of the 6-pole rating. However, since the coil throw on four poles is only 120 deg. the chord factor is sine

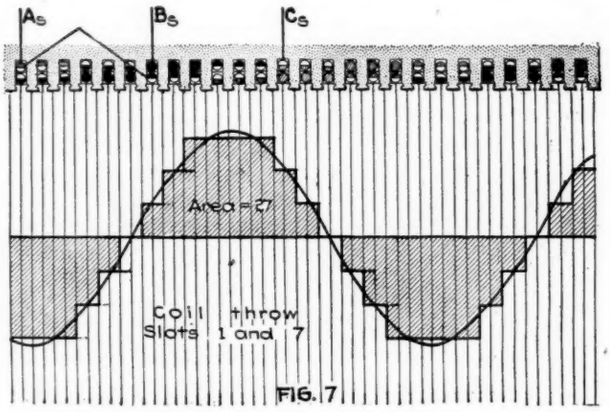


FIG. 7

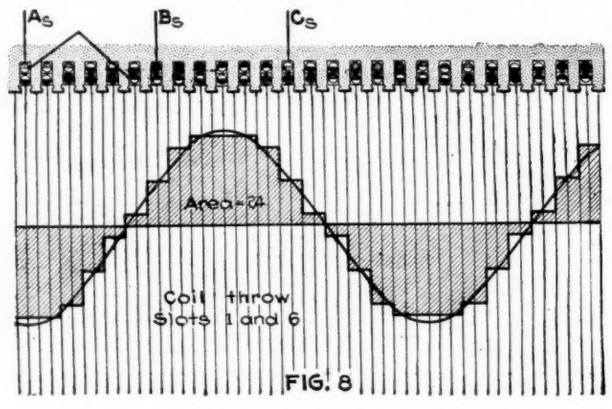


FIG. 8

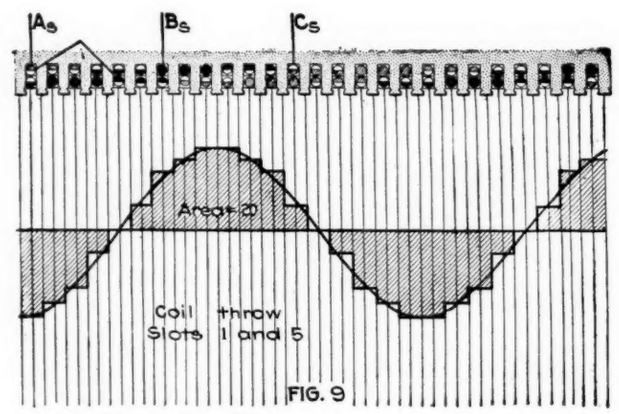


FIG. 9

(d) ○ = − 1.0 Ampere, Phase B
(e) ◔ = − 0.5 " " A
(f) ◑ = − 0.5 " " C

FIGS. 4 TO 9. SHAPES OF MAGNETIC FIELDS OF A 54-SLOT THREE-PHASE 6-POLE INDUCTION MOTOR WHEN THE THROW OF ITS COILS IS CHANGED FROM SLOTS 1 AND 10 TO SLOTS 1 AND 5 BY ONE-SLOT INTERVALS

Explanation of symbols used: *e*, *a* and *f* are the instantaneous values of the currents in phases *A*, *B* and *C* respectively, for angle 0 deg. as given in Table I. It is assumed that positive currents flow toward the reader and that negative ones flow away from him; the former are represented by the solid black symbols, and the latter by the hatched ones. When the currents *e*, *a* and *f* make their return through the other side of the coils their direction in reference to the observer is reversed and they are then represented by the symbols *b*, *d* and *c* respectively.

four poles, although it was full pitch, or 180 deg., when connected for six poles. It will be noted that with the 6-pole winding, Fig. 4, the entire area of the poles is $6 \times 32 = 192$, but that for the 4-pole winding. Fig. 10, the area is $4 \times 61 = 244$. In the 4-pole winding. the speed of the rotating field is 1.5 times that of the 6-pole one, and it would therefore seem reasonable that of 60 deg. = 0.866 and the rating will be reduced by this fact so that only 1.5×0.866, or about 1.3 the 6-pole horsepower can be expected. The total areas of the two fields as previously noted—namely, 244 and 192—have the relation $\frac{244}{192} = 1.27$, which is very close to 1.3, so it follows that a close aproximation of the output to be expected from a reconnected motor can be

obtained by this simple method of plotting the magnetic fields and comparing the areas. The difference in the saturation of the stator iron would affect this result to some extent, but usually not enough to introduce a serious error.

In Figs. 11, 12 and 13 is shown the effect upon the magnetic field of reconnecting the winding shown in Figs. 2 and 4 for 8, 10 and 12 poles, respectively. The effect of chording becomes more pronounced with each step, and the decreased area of the magnetic field shows that with the decreasing speed the horsepower

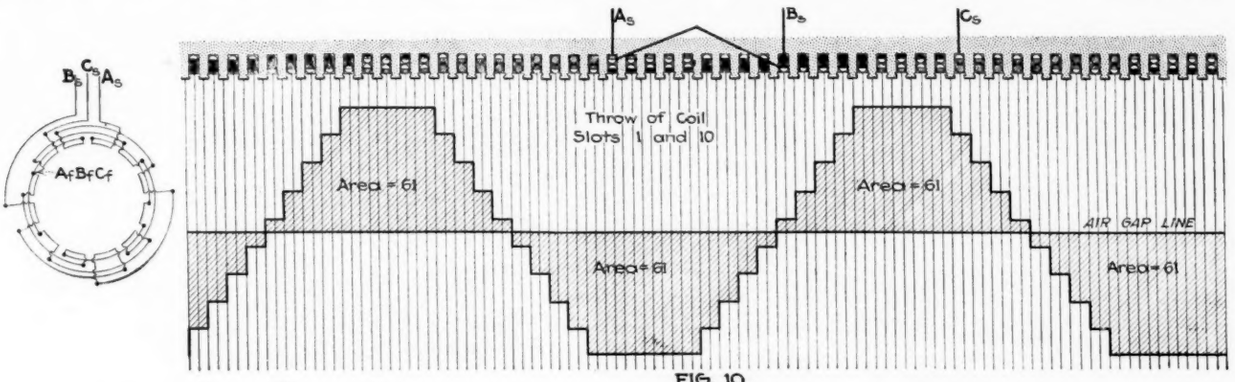


FIG. 10

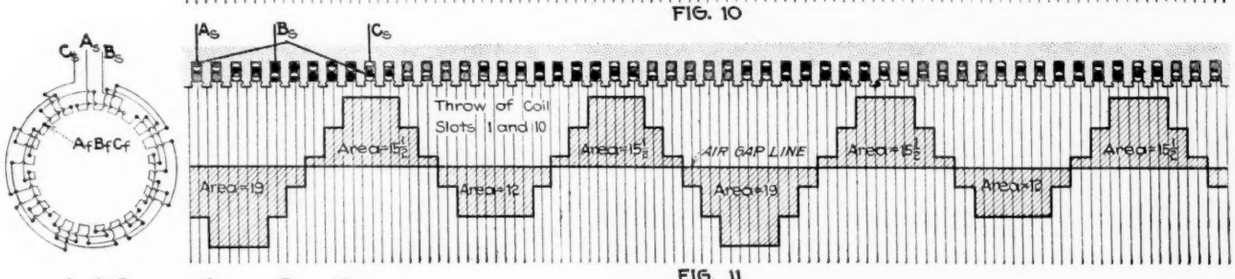


FIG. 11

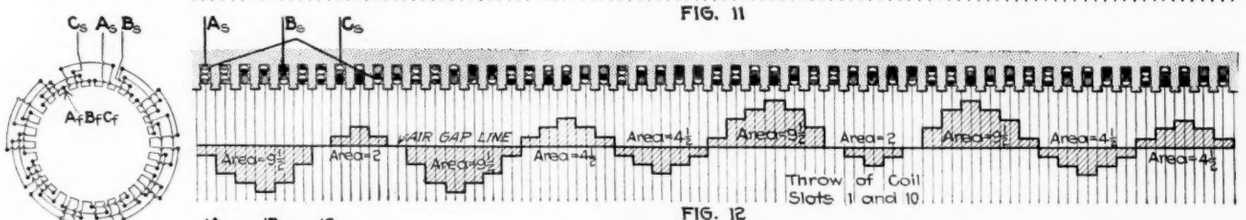


FIG. 12

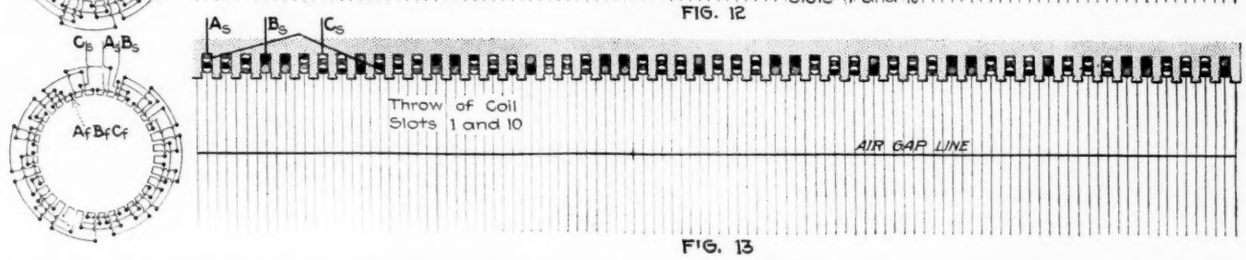


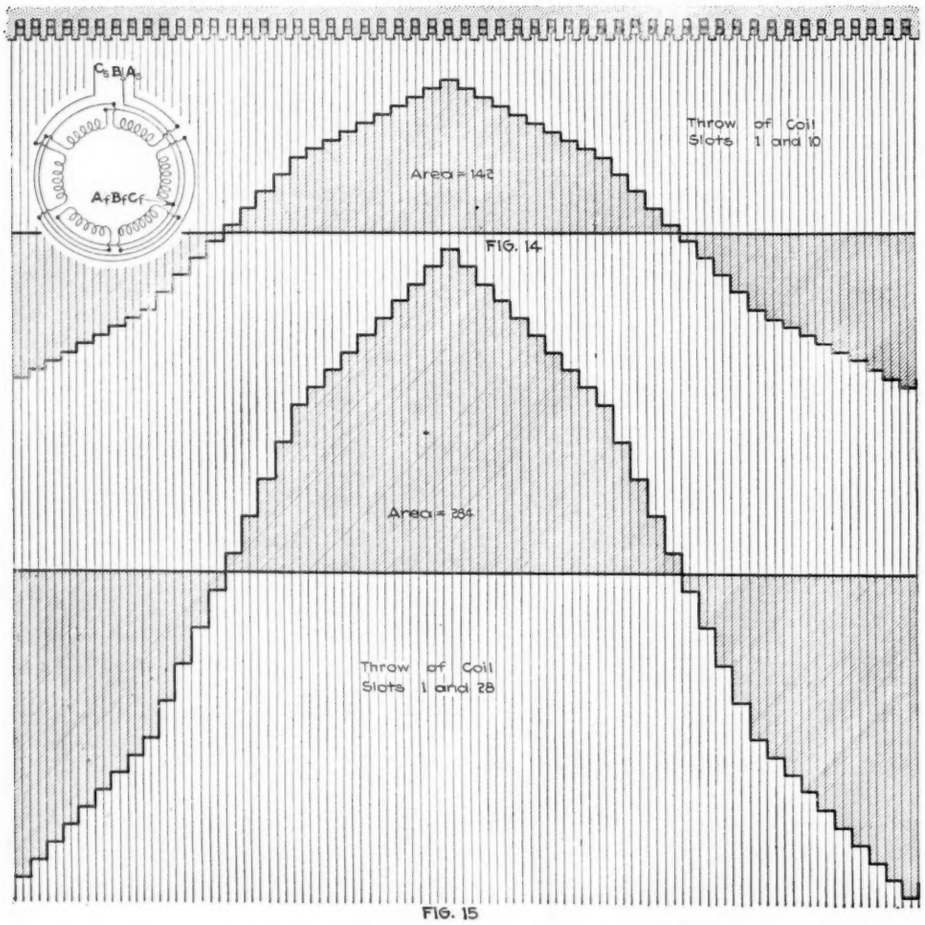
FIG. 13

FIGS. 10 TO 13. SHAPES OF MAGNETIC FIELDS OF A 54-SLOT THREE-PHASE 6-POLE INDUCTION MOTOR OF A COIL THROW OF SLOTS 1 AND 10, WHEN RECONNECTED FOR 4, 8, 10 AND 12 POLES

decreases also until finally in Fig. 13 an impossible condition is reached under which the motor could not run at all, since the throw of the coil is exactly pitch for 6 poles and therefore substantially becomes dead when connected for 12 poles; or putting it another way, the throw of the coil is such that when there are 12 poles both sides of any given coil lie in exactly the same polarity; one side is under a north pole and the other, instead of being under a south pole, reaches clear across and lies under the next north pole, so that the counter-electromotive force, which is generated in one side of the coil, is exactly balanced and neutralized by the voltage generated in the opposite side and there is no counter-electromotive force left to oppose the applied electromotive force at the stator terminals, consequently, the current in the stator winding is limited only by the ohmic resistance of this winding, and would cause the circuit-breaker to open, or, if the motor was not properly protected, cause the windings to be destroyed in a very short period. Attention was called to this point in an earlier article when speaking of the possibility of connecting some windings as they stand for double or half speed; that is, for half as many poles or twice as many poles. The statement was then made that this should not be attempted if the throw of the coils was exactly pitch on the original winding. Fig. 13 explains why this is true and why such a reconnection is not feasible.

In Figs. 14 and 15 is shown a very interesting comparison. Fig. 14 shows the result of reconnecting the 6-pole winding of Figs. 2 and 4 for two poles. Ordinarily, this would not be possible because a 2-pole motor would require about three times the radial depth of iron behind the slots as is required by a 6-pole one; but assuming for illustration that such a reconnection

had been attempted, the field would have the appearance shown, and it will be seen that the area of one magnetic pole would be 142. Suppose, on the other hand, that instead of reconnecting, the motor had been rewound with coils having a throw of 180 deg. for two poles or full pitch, as shown in Fig. 15; then the area of the field would be 284 for one pole or just twice the value for the reconnected motor. Since, as has been shown, the comparative areas of the two poles are some measure of the output to be expected, it can be at once concluded from Figs. 14 and 15 that the use of a new set of coils would double the output of the motor and that



FIGS. 14 AND 15. MAGNETIC FIELD OF A 54-SLOT THREE-PHASE 6-POLE INDUCTION MOTOR OF COIL THROW 1 AND 10, WHEN RECONNECTED FOR TWO POLES, COMPARED WITH EFFECT OF REWINDING IT FOR TWO POLES WITH A THROW 1 AND 28

it would be poor economy in such a case to reconnect instead of rewinding.

This paper completes the subject of reconnecting for changes in poles, and from the figures given it may be seen that the first consideration in such changes is the question of chord factor, and the comparisons made give a good idea of the effect upon any motor of changing the throw of the coil. The main value of the latter idea is that it is often possible when reconnecting a winding to assist in getting normal conditions in the winding by changing the throw of the coils by a slot or two in a certain direction.

Extreme temperatures are destructive of furnace lining. Perhaps this is why so many firemen are so careless regarding the admission of excess air to their furnaces.

Destruction of the French Coal Mines*

The French Departments du Nord and Pas-de-Calais have suffered severely through the depredations of the invader. The Germans, in their customary manner, destroyed the greater part of the machinery used at the coal mines. As a result of their ruthlessness, France is deprived of one-third of her normal output of coal for a period of three or four years to come. Whether the German debt shall be paid by occupying the district of La Sarre or by a coal tax upon the Rhine and Westphalian districts is unimportant, but fuel must be one of the most important considerations in the peace treaty. The destruction of equipment was thorough at Lens, Courrieres, Dourges, l'Escarpelle, and Douai. At Aniche and Anzin it was hoped, for a moment, that less destruction would be apparent, but it is just the same. Steam cylinders and air compressors were dynamited. A few cartridges carefully exploded in screen and washing plants have made them useless. Switchboards were carried away, and no trace of copper is to be found. Here and there are a few cars still loaded with coal, but most of them lie around partly destroyed by near-by explosions.

In the district of Lens the mines were flooded by turning surface water into them. In other districts only the lower levels of the mines are now flooded, owing to the cessation of pumping. By the middle of October scarcely a single inhabitant of the coal districts remained. A few miners hid themselves and stayed behind the retreating Germans, and others, escaping from the retreating enemy, are now slowly coming back to the mining districts, and civil life is beginning again.

The engineers and superintendents who had remained at the mines during the war were taken to Belgium in the retreat and are still prisoners.

A few engineers who were formerly connected with the mines are in France, and these are now returning to take such care of the property as is possible and to begin restoration.

At a few mines the destruction was not so complete as intended, and many inhabitants still remain; the Germans, with bayonets at their backs, could not always complete their tasks.

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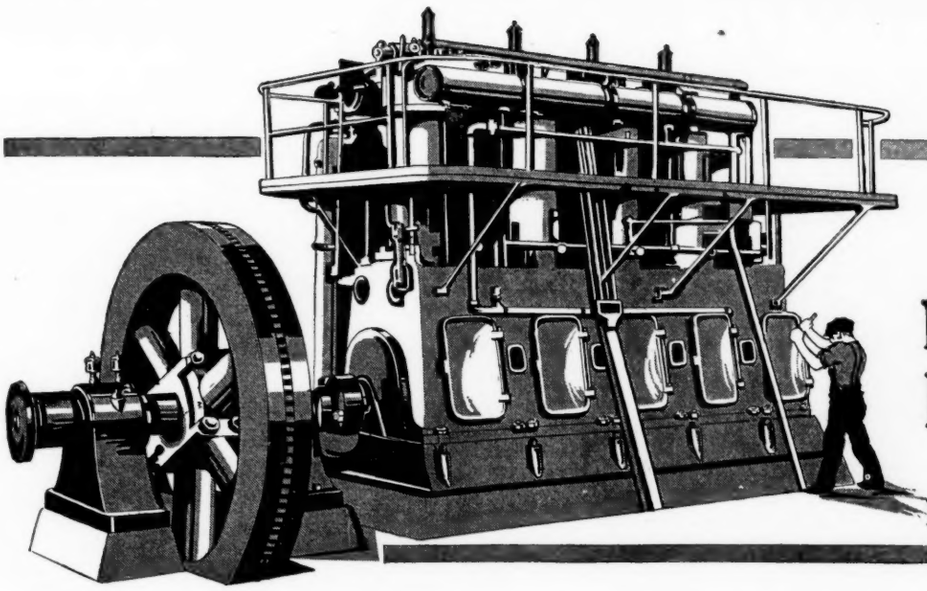
*Extract from *L'Echo des Mines et de la Metallurgie*, Nov. 3 and 10, 1918.



Talks on DIESEL Engines

by L. H. Morrison

I—The first of a series of imaginary conversations between the chief engineer of a Diesel-engine plant and his men, intended to bring out information as to the constructional features and practical operation of the Diesel engine.

IT WAS just six o'clock and the night shift had come on duty at the Diesel-engine station of the Clarksville Power and Light Co. Two 500-hp. vertical engines were working at their full capacity, and over in one end of the building the oilers were preparing a third to aid in carrying the load.

J. R. Egan, the chief of the plant—affectionately known among the men as "J. R."—got up from his desk near the end of the switchboard and stepped into the washroom, where he stood for a moment watching the day force ridding themselves of the grease and grime peculiar to their calling.

"Boys," said Egan, "I want to say a word to all of you before you leave. When you get washed up, come over to my desk." A buzz of conjecture followed the chief's retreating figure, but in a few minutes the men stood around the desk. When he had assured himself that all the force, including the night shift, had assembled, J. R. bit off the end of a particularly vile-looking cigar and addressed the men.

LIEUTENANT MORRISON

"Before I begin on my main subject," he said, "I want to explain the wherefore of my having a subject at all. Today Jim Woods here"—indicating a young fellow at the outer fringe of the crowd—"came asking for the job of oiler that we had vacant. Now, as you all know, we pay the oilers but sixty per month, and I knew Jim was running that hot-ball engine at the Acme mill and was getting seventy-five. I couldn't understand why he wanted to work for less, for Green the miller told me the other day that Woods was the best man they ever had.

"When I put the question up to Woods, he told me he wanted to get some experience with Diesel engines because he thought there was going to be a demand for good Diesel engineers. Consequently, he was willing to start in for less money.

"Now, boys," the chief continued, "Woods set me to thinking. As I look back, I can't remember that I ever tried to train any man who worked here. While I've often given suggestions, I suspect that whatever you fellows know about oil engines you have picked up yourselves. To make matters worse, I heard Kelly here tell Woods that the reason the Diesel is the most economical engine is because it burns up all the fuel. But I don't blame Kelly. It isn't often one sees any articles on Diesel-engine theory, and when you do find one, it is usually chuck-full of mathematics too deep for ordinary understanding.

"Now, my idea is this, boys. Suppose we form a class here at the plant to study the Diesel engine. We can get together two evenings a week, say from 8 to 9:30 and the night men can arrange their work so as to join us. My plan would be to take up the construction and action of the Diesel, as well as some other types. Besides, we could discuss various problems that come up in operating these engines. What do you think of the scheme?"

Kelly, the day watch engineer, was the first to reply.

"J. R., I think it's a good plan. If it means giving us a chance to get more money, I'm willing to come every night. Eighty-five a month for a twelve-hour shift isn't enough money these days, and I can't see why the company don't pay us more. I'm not kicking, mind you—I'm just stating facts. Jim Woods here can live on sixty, for he's single. But what about the rest of us?"

"Boys," said the chief sternly, "if this is to be the beginning of grumbling, we'd better drop the idea. I agree that wages are too low, but it isn't the company's fault. If you go back far enough, you'll find that the real cause of low wages is the attitude of the oil-

engine builders. In order to sell Diesel engines their two big claims were the small amount of fuel used and the fact that any ordinary man could run a Diesel. In fact, I heard a salesman for a prominent builder say that after the engine was started it was only necessary to lock the door to keep small boys out and the engine would continue to run as long as the fuel oil lasted."

When the laughter of the men had died down, the chief continued:

"Last year the representative of a Diesel-engine builder stated in a machinery magazine that skilled attention wasn't essential—it was only necessary for the operator to be intelligent. With such stuff being handed out, can you blame the purchaser of a Diesel engine for placing you on a par with the day laborer? That the engines do run is due to the fact that occasionally a good man is willing to work awhile at low wages. In this plant, during the last two years, more than twenty men have left—quite different from the ice plant, where the engineers and firemen have been on the job for ten years at least."

"Where does this night school help, then?" Kelly suddenly inquired.

The chief studied the end of his unlighted cigar thoughtfully before he replied.

"In this way," he said at length. "The men we usually hire are either poor help or else they get dissatisfied and quit. Now, if you men will go into the Diesel game right, it's only natural that the local manager will see that you are worth more and will come across; or else you will find some other firm willing to pay for valuable services. In either case, you win. If there was a good correspondence-school course on the subject, I'd suggest that; but under the circumstances we'll fix up a course of our own as we go along."

"I'm willing," Kelly said promptly.

"So am I," came from a number of others.

"Do you think the idea good, Woods?" asked J. R.

"That's the very thing I started working here to get," answered the newcomer.

"Very well, then; if you're all agreed, we'll begin tomorrow night, as it's Tuesday, and we'll have a session Thursday night, too."

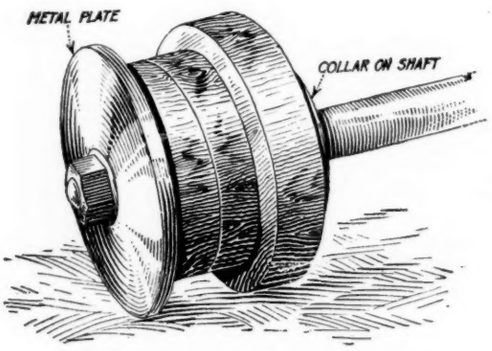
Emergency Pump Repair

An electrically driven pump was not working properly. The water in the mine at this time was already above the rails, so that the section could not be operated that day. Taking the pump apart, it was found that the metal portion of the piston had been practically eaten up by the acid of the water. A new piston and a piston rod were at once ordered. These were promised to arrive on the following Monday morning.

Monday morning came, but no piston arrived. Tuesday and Wednesday rolled around, and still no piston. All this time the water was rising. Something had to be done, or at least attempted. Accordingly, I got a piece of 2-in. oak plank and sawed out a circular section $\frac{1}{4}$ in. less in diameter than the bore of the pump cylinder, says S. D. Hainley in *Coal Age*. The edge of this was then cut away to a depth sufficient to take $\frac{3}{8}$-in. packing and for a length of 1 in. A piece of 1-in. oak board was then procured, sawed to this same diameter and attached to the piece of 2-in. plank to make the piston of the proper length.

As the available length on the piston rod was not sufficient to accommodate another 1-in. piece, a metal plate was used. This was made slightly smaller than the bore of the pump and was held in place by the regular piston-rod nut.

When this improvised piston was fitted with packing and put in place, it gave as good satisfaction as had the



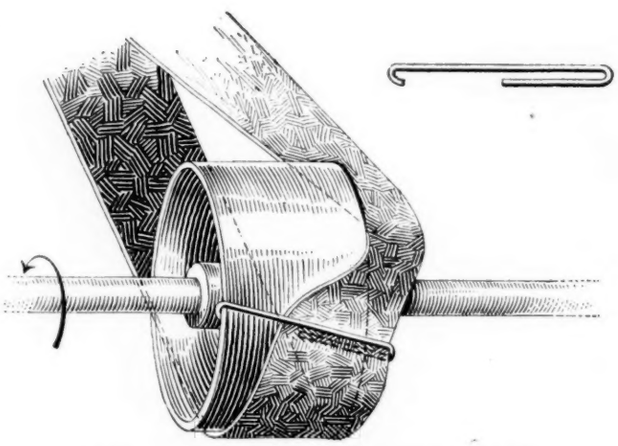
HOW PUMP REPAIR WAS MADE

regular piston. In fact, it gave excellent service until the acid ate up the iron plate and permitted the packing to come off. When I asked the superintendent to have another plate made, he immediately suggested that I make a wooden one!

Putting on Heavy Belts

The illustration shows a simple device for putting on heavy belts when it is necessary to shut down in order to do so, and where a rope is usually employed for the purpose.

Take a piece of $\frac{1}{4}$- or $\frac{5}{16}$-in. round iron and bend it, as shown in the small sketch. Hook the short end over the edge of the rim of the pulley and the long end under



METHOD OF REPLACING BELT ON PULLEY

the belt as indicated. Start the engine slowly, and when the belt is on it is not necessary to stop, because the short end of the hook will straighten out and disengage itself. It is a good plan to use a rod of as light weight as will answer the purpose, since it will straighten out and free itself with less stress on the belt. The iron hook then falls to the floor.

Burning Indiana Coal on the Chain Grate

By T. A. MARSH
Chief Engineer, Green Engineering Company, East Chicago, Ind.

Characteristics of Indiana screenings from the four seams supplying most of the steaming coal. The need of large grate area, large furnace volume and strong draft to give capacity and long, high-pitched arches to improve ignition. Possibilities of improving existing furnaces.

ALTHOUGH Indiana is the fifth state in tonnage of coal produced, its fuel, until the zoning system went into effect, was not widely distributed. Recently, Indiana coal has been used in many cases where its characteristics are not understood and where the existing furnaces are unsuitable for efficient burning. Plants that have been designed for West Virginia, Kentucky or Ohio coals, usually are not suited for Indiana coal and will not give satisfactory results.

The standard coals in Indiana are found in four seams: Nos. 3, 4, 5 and 6. In addition there are

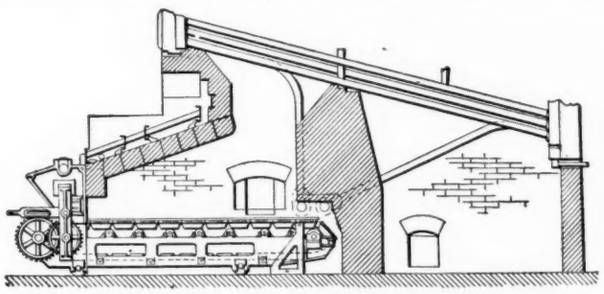


FIG. 1. TYPICAL CHAIN-GRATE SETTING UNDER VERTICALLY BAFFLED WATER-TUBE BOILER

produced a few special grades, but these are not classed as steaming coals and will not be considered. Steam producers are interested almost entirely in the quality of screenings, so that the conclusions following will be based on this fuel. The accompanying table gives proximate analyses, heat values and sulphur content of typical screenings from the four Indiana seams. These analyses cannot be compared on an equal basis with samples of coal as usually submitted, because such

ANALYSES OF INDIANA SCREENINGS

	No. 3 Seam	No. 4 Seam	No. 5 Seam	No. 6 Seam
Moisture	10.8	12.4	10.1	11.0
Volatile matter	35.0	33.2	33.2	31.1
Fixed carbon	36.9	44.2	42.0	41.5
Ash	17.3	10.2	14.7	16.4
B.t.u., commercial	10,400	11,069	10,820	10,540
B.t.u., dry basis	11,670	12,610	12,039	11,730
Sulphur	4.55	1.75	4.27	3.50

samples are based on run-of-mine or lump coal. Screenings contain usually 4 per cent. more ash than run-of-mine coal and approximately 6 per cent. more ash than lump samples. Naturally, the screenings are correspondingly lower in heat value. The characteristics of the coal from the various seams may be of interest.

No. 3 coal, while not high in heat value, has the highest percentage of volatile matter and therefore gives up its heat more quickly than the others. It is an excellent coal to use to get capacity in furnaces that are deficient in ignition arches or draft, or in both of these items. The structure of the coal is soft. It therefore disintegrates readily and is not a good storage coal. Its relatively high percentage of sulphur further complicates the storage problem and the fusibility of the ash causes excessive clinker when the fuel bed is

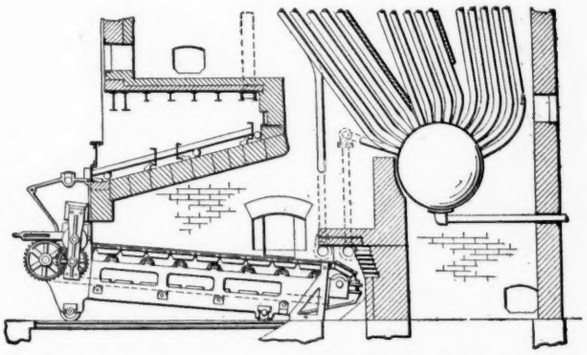


FIG. 2. MODERN FURNACE SERVING STIRLING BOILER

agitated. The produced tonnage of No. 3 coal is not large, and the distribution is therefore limited.

From the commercial standpoint No. 4 has the greatest utility of all Indiana coals. Its heat value is relatively high for a Western coal, the sulphur content is low and the coal in this seam is of uniform quality. The fixed carbon is of such good structure that when used in byproduct ovens excellent coke is produced. Owing to its uniformity and low sulphur content, No. 4 is in great demand for special process work, such as forges and heating furnaces, and commands a higher price than other Indiana coals. It is better adapted for stoker use than the other fuels mentioned, and this applies particularly to stokers that agitate the fuel bed. With fireclay above and below a large portion of this coal seam, the clinker produced is of a "pottery" brittle nature.

From the standpoint of steam production No. 5 is the most important of the Indiana coals. Its high percentage of sulphur makes it unsuitable for special

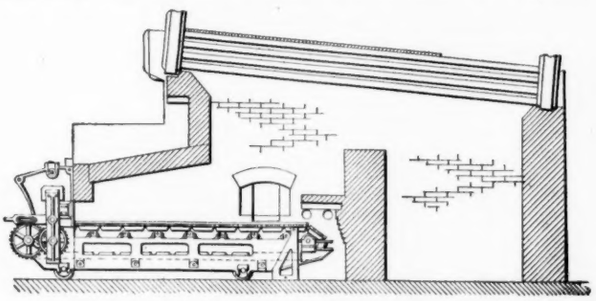


FIG. 3. CHAIN GRATE UNDER HORIZONTALLY BAFFLED BOILER

process work, but on account of the large quantity produced and the assurance of supply, together with its uniformity and free-burning characteristics, it is recommended for steam-power plants. It burns more rapidly than No. 4 coal, inasmuch as the fixed carbon does not have the structure found in the latter fuel. A consider-

able portion of this seam has rock above and below so that there is no clay mixture to keep the clinker brittle, and although the coal is clean as regards earthy matter, the clinker produced is extremely vitreous. This coal is suitable for chain grates, but the furnace design must be such as to give good strong ignition, a point that in many instances has been overlooked.

No. 6 coal contains a higher percentage of ash than any other extensively used Indiana coal. Its moisture is slightly less than that of the No. 4, and the heat

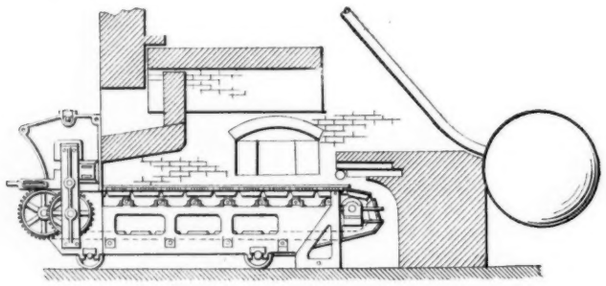


FIG. 4. FURNACE DESIGN TWELVE YEARS AGO

value is approximately 5 per cent. less, due to the higher ash. The ash fuses at a low temperature, making it difficult to handle. Unless the proper type of stoker is used, this coal cannot be considered, owing to the large amount of clinker produced and its vitreous structure. Use of No. 6 coal is still more limited than of No. 5, by reason of its lower heat value and the greater amount of clinker produced. It requires liberal grate areas and long arches to provide ample ignition, if good steaming capacity is to be had.

For the sake of economy in the purchasing of coal and in its burning, plants tributary to Indiana should be able to burn coal from the four seams mentioned and particularly from Nos. 5 and 6 seams.

The design of furnaces for these coals must be given careful thought. Many furnaces have been inadequate, mostly because of lack of knowledge of the coal and

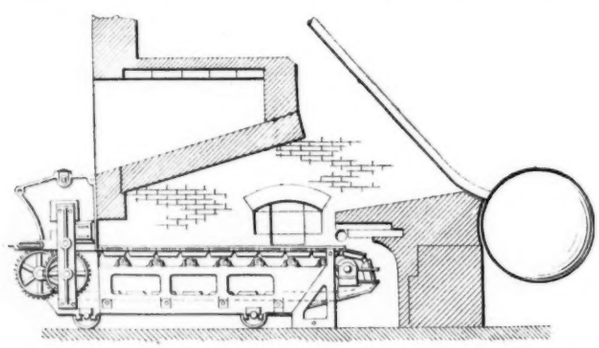


FIG. 5. REVISION OF FURNACE SHOWN IN FIG. 4

of the furnace design necessary. Large grate surfaces should be provided as these coals are relatively inert, and even with high combustion rates the capacities obtained do not correspond unless the grate areas are large. Four things must be considered in the design of furnaces for such coals as Indiana Nos. 3, 4, 5 and 6.

Ample draft must be provided. These coals can be burned at combustion rates of 40 to 45 lb. per sq.ft. of grate area per hour with a draft of 0.4 to 0.5 in. over the fire. Long, high-pitched igniting arches should be provided. Grate areas should be liberal with coals so low in heat value. If high capacities are to be obtained, grate areas should be provided having a ratio to the steam-making surface of 1 to 40 or even larger. Furnace volumes should be large. In furnaces where 40 lb. of coal per hour per square foot of grate area is to be burned, the furnace chamber should have a volume of 12 cu.ft. per sq.ft. of grate area, and furnaces even larger are desirable.

Advantages of Large Grates

Large grates are an advantage, as they permit high efficiencies at capacities 200 per cent. of rating and upward. A characteristic of chain grates seldom emphasized, but well known to combustion engineers, is the high efficiencies that can be obtained at ratings below normal. Many types of stoker cannot be operated appreciably below 100 per cent. of rating, owing to overheating, back draft or other difficulties. Still other types operate at low ratings but at reduced efficiencies. Chain grates reach excellent efficiencies at from 50 to 75 per cent. of rating. With inferior coals, therefore, large grates should be installed as this will insure high

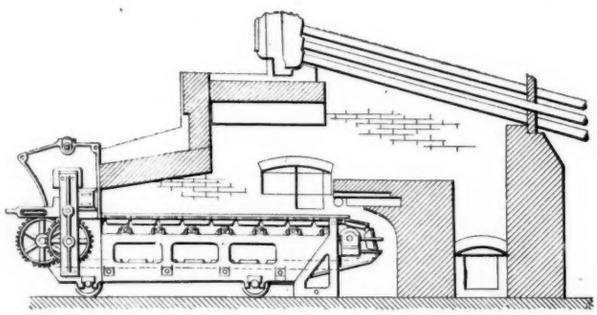


FIG. 6. OLD FURNACE EQUIPPED WITH SPRUNG ARCH

ratings when desired and will also give high efficiencies at lower ratings.

Unfortunately, many of the chain-grate installations do not have these characteristics and capacities and efficiencies are consequently limited. Modern settings, however, give combined efficiencies of from 70 to 75 per cent. when burning any one of the four coals under discussion, and develop boiler capacities 200 per cent. of rating and over. With chain grates these coals are handled indiscriminately. There is no clinker formation, as the ash forms on the lower side of the fuel bed and there is no agitation of the fuel bed. Moreover, the ash is continuously discharged from the furnace, permitting no accumulation of refuse, and air spaces are kept clean continuously by the staggered arrangement of links.

Some typical modern settings capable of producing high ratings and high efficiencies, are shown in Figs. 1, 2 and 3. Fig. 1 shows a modern chain-grate furnace under a vertically baffled water-tube boiler. Notice that the length of the arch is 75 per cent. of the length of the grate and that the grate is 11 ft. long. This may be increased to 13 ft. or even 15 ft. if the arch is lengthened correspondingly. The arch is steeply pitched and the face of the bridge-wall is built up vertically. The headroom is 12 ft. This furnace, provided with a draft of 0.5 in. over the fire, will burn 40 lb. per sq.ft. of grate area per hour of any one of the four Indiana coals. Fig. 2 shows the application of the

same principles to a Stirling type of boiler and Fig. 3 to a horizontally baffled boiler.

It will be noticed that all these furnaces have large volumes. The furnace volume per square foot of grate area in Fig. 1 (allowing for a grate width approximately equal to that of the furnace) is 12 cu.ft. The furnace volume in Fig. 2 is 12 cu.ft. and in Fig. 3 is 13 cu.ft. In installations dating prior to 1916 the furnace volumes commonly found ranged approximately from 3 to 6 cu.ft. per sq.ft. of grate. The average length of arch was 4 ft. and the average draft about 0.25 in. over the fire. Even under these conditions Indiana coals were handled without clinker trouble, but in a limited manner

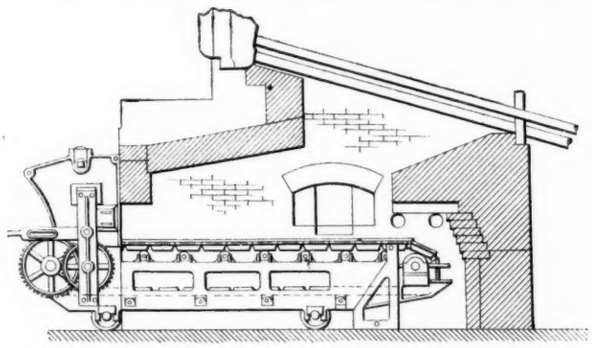


FIG. 7. REVISION OF FIG. 6, INCREASING CAPACITY AND RANGE OF COALS AVAILABLE

as regards efficiency and capacity. The results from modern furnaces are far superior.

Fortunately, most existing furnaces permit of revision that will greatly improve capacity and efficiency. Modern arch construction can be installed. Arches can be set higher to give more furnace volume and can be made longer to improve ignition and distill off the volatile matter more rapidly. This gives better opportunity for the complete combustion of the fixed carbon. Bridge-walls can be modified to reflect the heat forward, helping the ignition, and by increasing the furnace temperature improve the combustion of the hydrocarbons.

Other Changes to Improve Results

A type of arch preventing air from immediately reaching the bottom surface and chilling it should be installed. This can be accomplished by setting the front row of tile lower than the main arch surface. This construction increases the temperature at the front of the furnace. These and other modifications can be made in most furnaces, and if at the same time the boiler baffles can be rearranged to increase the draft, higher capacities and efficiencies can be obtained and the range of coals available can be widened. Many plants have already revised their furnaces with improved results. Some typical cases are shown in Figs. 4 to 7 inclusive.

Fig. 4 represents the design of a furnace installed under a Stirling type of boiler twelve years ago and Fig. 5 the recent revision of this furnace. With the original furnace only the better grades of Indiana coals could be used. In the improved setting one continuous arch, 7 ft. 6 in. long, replaces the old sprung arch. After the revision it was found that the lower grades of Indiana coals could be nicely handled, inasmuch as the draft and grate area were adequate and the ignition was better. Fig. 6 shows a furnace installed several years ago under a vertically baffled horizontal water-tube boiler and Fig. 7 the revision which materially increased the capacity and the range of coals available.

From the foregoing discussion the following conclusions are evident:

1. Indiana coals are being and will be extensively used.

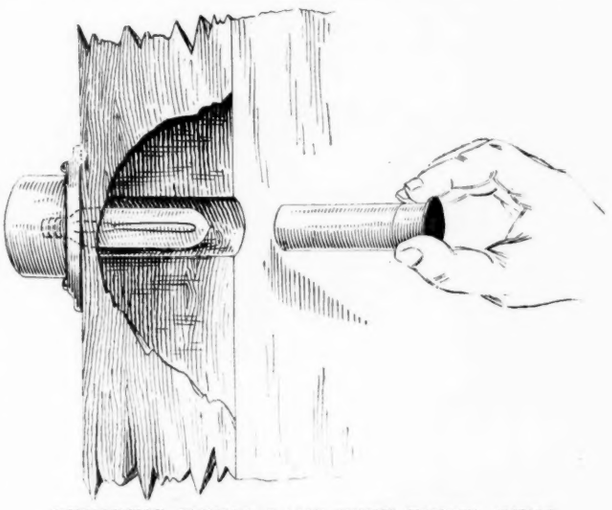
2. The characteristics of some of these coals are low fusing temperature of the ash, great tendency to clinker and large amount of clinker.

3. These coals give serious clinker trouble when the fuel bed is agitated. Continuous ash removal is preferable. With chain grates in modern furnaces, high capacities and efficiencies can be obtained from all grades of Indiana coal.

4. Existing furnaces permit improvement. Each should be considered in the light of modern engineering knowledge and can be revised, widening the range of coals to include all Indiana seams and increasing the capacity and efficiency under all conditions.

Removing Signal Lights with Shell

Tubular signal lamps as used in remote-control switchboards and similar apparatus are commonly removed, when it is necessary to replace or change them, by going in back of the board and taking off the removable socket to get at the lamp. It is sometimes difficult to locate the desired lamp from the back



REMOVING SIGNAL LAMP WITH EMPTY SHELL

of the board, and frequently the back of the switchboard is not easily or safely accessible.

These indicating lamps can be far more easily removed by taking them from the front of the board with the aid of a 12-gage paper shotgun shell. The little colored glass window in front of the lamp can be easily lifted out with the fingers and an empty paper shell slipped over the lamp. The shell is of such a size that while the lamp will partly enter it, it fits tightly. It can then be easily removed by turning the shell, and a new lamp can be inserted in the same manner.

The Electrical Study Course—Parallel Operation of Generators

Discusses the object of operating several generators in parallel and the conditions which must be fulfilled by them. Shows the necessity of using an equalizing connection when dealing with compound-wound machines, and the method of its functioning.

WHEN a constant load is to be supplied with electrical power, a single generating unit may be installed to provide the energy, its capacity being just large enough to take care of the load, since it operates at highest efficiency fully loaded. On the other hand, when the load varies greatly from one part of the day to another, it would be uneconomical to supply power from a single unit because it would be operating considerably below full load, and therefore at a low efficiency, for much of the time. Under such circumstances it is usual to provide two or more units of such capacities as will allow of their operation at as nearly full-load conditions as possible at all times.

When two or more generators are furnishing power to a load fed by them all, they are said to be operating in parallel, and the act of connecting one of them to the others is known as "paralleling" it. In order that generators of any kind shall work together satisfactorily, it is necessary that they divide the load among themselves correctly. That is, each must take its due share. The question raised is, therefore, Will any two generators operate successfully when connected in

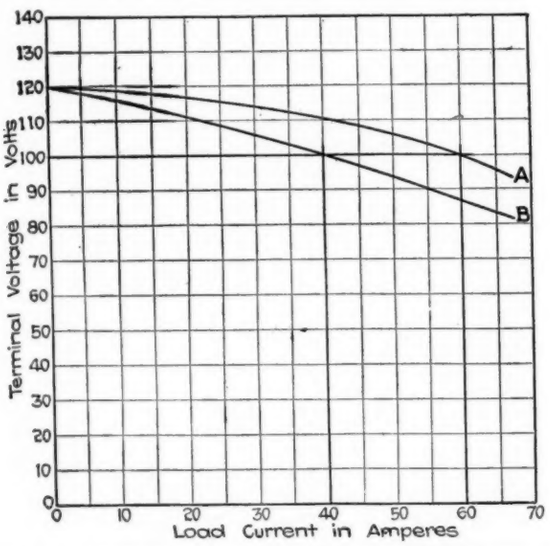


FIG. 1. DIFFERENCE IN SHAPE OF THE EXTERNAL CHARACTERISTIC CURVES OF TWO SHUNT GENERATORS OF UNLIKE DESIGN

multiple? In order to answer this it is necessary to inquire into the factors controlling their behavior. For this purpose we must go back to the theory of the generator, in which it was shown that the current delivered by it is equal to the difference between the generated and terminal voltages divided by the armature resistance. That is, if I represent the armature current, E_g the generated voltage, E the terminal voltage, and R the armature resistance, we have, $I = \frac{E_2 - E}{R}$, from which it is seen that E_g and R must bear certain relations to each other. If the machines

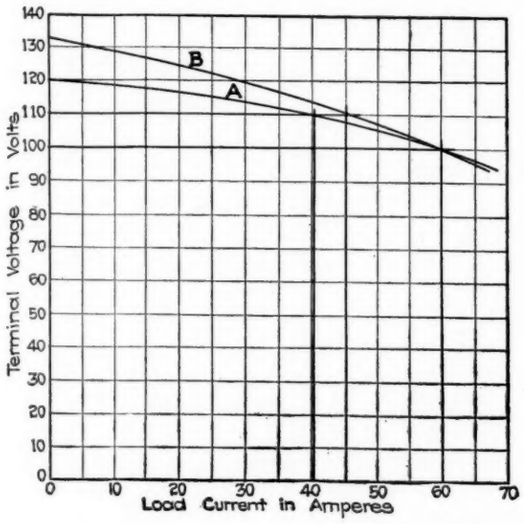


FIG. 2. EXCITATION OF GENERATOR B INCREASED TO MAKE IT TAKE SAME LOAD AS A AT 100 VOLTS

are of the same size, the relation betwen the values of these quantities in each must be such that I is the same in all; if they are of different sizes, the relations must be such that I in each case is proportional to the capacity of the machine.

The relations existing between current, armature resistance, generated voltage and terminal voltage are governed by the characteristics of the machine. Their effect upon its behavior is most readily determined by reference to the External Characteristic Curve of the machine. This, as will be remembered, is a curve showing the relation between the current delivered by a generator and its corresponding terminal voltage. For a shunt generator its shape would be such as that of the curves shown in Fig. 1, which represent the characteristics of generators of the same size but of different designs. Although having the same voltage at no load—namely, 120 volts—they do not undergo a like decrease in voltage for similar increases in current. For example, at 100 volts the machine of curve A would be taking 60 amperes, whereas that of curve B would be taking only 40 amperes. By increasing the excitation of B or decreasing that of A, the machines could be adjusted to take the same current at 100 volts, being 60 amperes in the former case and 40 amperes in the latter. These conditions are illustrated in Figs. 2 and 3 respectively.

If these two machines were connected in parallel, they would divide the load equally when it happened to be 120 amperes in the one case or 80 amperes in the

other. If they were operating under the conditions of Fig. 2 and the common load were decreased, the current delivered by each machine would decrease and consequently its terminal voltage would increase. Since the machines are connected together, their terminal voltages would be the same and we will assume that a value of 110 volts is found to exist. At this voltage machine *A* would deliver about 41 amperes, whereas *B* would deliver about 45 amperes, the total load being the sum of the two, or 86 amperes. It would require further field-rheostat adjustments to make the generators divide the new load equally between them. In like manner we will find that any other change in load will cause an unequal distribution.

On the other hand, if both machines had precisely the same characteristic, the current in each would be half the total at all times, since at the same terminal voltage the same value of current would be delivered by each. Consequently, we conclude that generators having unlike external characteristics will not operate in parallel satisfactorily and, conversely, that such as have similar characteristics will do so.

If the generators are of different capacities, their characteristics must be such that the total load will

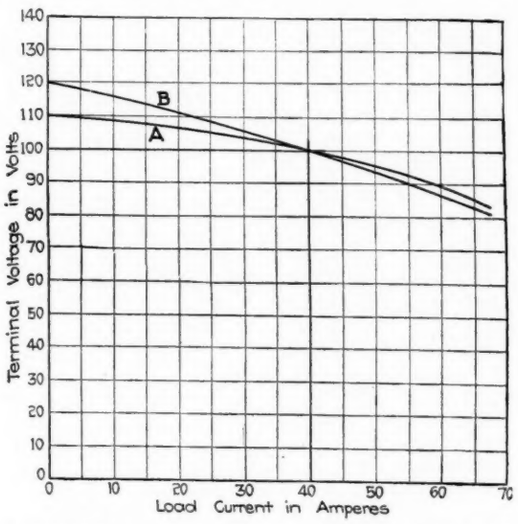


FIG. 3. EXCITATION OF GENERATOR A DECREASED TO MAKE IT TAKE SAME LOAD AS B AT 100 VOLTS

always be divided among them in the proportion of their ratings. Thus, in Fig. 4 characteristic *C* is that of a generator whose capacity is half that of the one having characteristic *D*. They both generate 120 volts at no load, as shown. A load of 30 amperes on one would reduce its terminal voltage to the same value as 60 amperes would on the other: namely, to 100 volts. At any other load the same ratio—that is, 1 to 2—would hold true, demonstrating that the machines would divide the load correctly if they were designed to develop the characteristics assumed.

The same course of reasoning can be applied to any other type of generator, such as the series and compound. Discussion of the former may be omitted, since it finds no practical application, but the latter is of great importance. Indeed, the compound generator has a far greater variety of applications than even the shunt type; it is the most important of the direct-current machines. We shall therefore proceed to treat of the parallel operation of such machines and learn what their peculiarities may be.

The external characteristics of overcompounded generators have shapes similar to those of the curves illustrated in Fig. 5, in which *F* is the characteristic of a machine more heavily compounded than the one whose characteristic is *G*, but of the same capacity. The dissimilarity in the curves will have the same effect

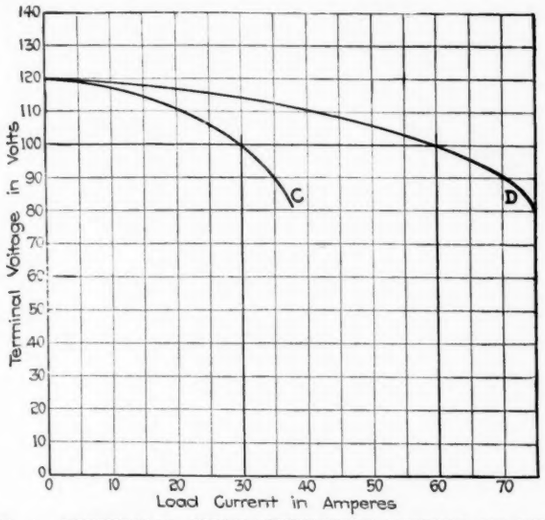


FIG. 4. EXTERNAL CHARACTERISTIC CURVES OF GENERATORS OF DIFFERENT CAPACITIES DESIGNED TO SHARE LOAD IN CORRECT RATIO

as in the case of shunt generators: that is, it will prevent the machines from assuming equal shares of the load. As with shunt generators, they could be made to assume the same terminal voltage for like currents by manipulation of the shunt-field rheostats, but they would not make such a division of the load of themselves. However, if possessed of identical external

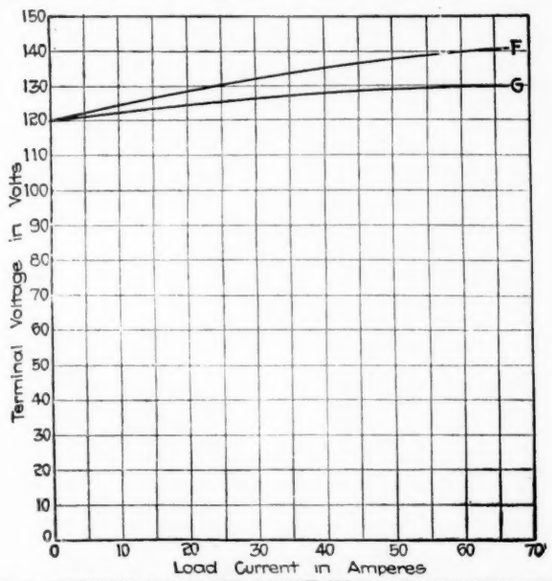


FIG. 5. EFFECT OF DIFFERENCE IN COMPOUNDING UPON THE EXTERNAL CHARACTERISTIC CURVES OF TWO COMPOUND-WOUND GENERATORS

characteristics, they will do so, in which respect also they behave as shunt machines would. We should therefore conclude, as in the case of the shunt type, that machines with unlike characteristics will not operate well in parallel, whereas those of like characteristics will.

The conclusions regarding shunt generators in parallel are borne out in practice, but it is found that compound generators refuse to operate properly even when their characteristics are identical, unless an additional feature, known as the equalizing connection—the necessity for whose introduction is not recognized as essential until a further study of conditions has been made—is provided.

In what follows an explanation will first be given as to why an equalizing connection, or equalizer, as

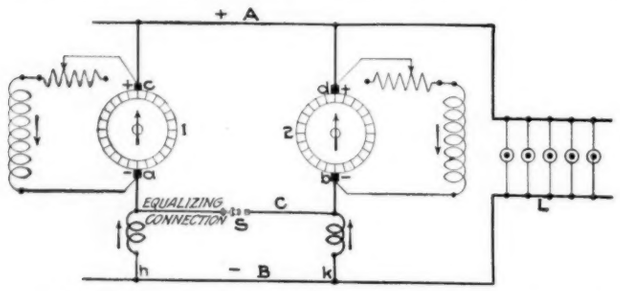


FIG. 6. METHOD OF CONNECTING COMPOUND-WOUND GENERATORS IN PARALLEL TO A LOAD

it is frequently referred to, is required when operating compound generators in parallel, and then will follow the reason for the satsifactory operation of shunt generators without any such device. To facilitate the discussion of the points involved reference will be made to Fig. 6, which shows two compound generators, 1 and 2, connected to the mains A and B, supplying current to a load L. Suppose A to be the positive and B the negative; then the direction of the currents through the shunt and series fields and in the armatures will be that indicated by the arrowheads. We will further suppose that the generators are of the same capacity and design, and that they are overcompounded alike. Also that it has been possible to place them in parallel and that each is therefore delivering half the current supplied to the load L. The following will show that the machines cannot maintain this assumed condition.

Anything affecting the generated voltage of either machine will affect its load current, since $I = \frac{E_g - E}{R}$. For example, the speed of generator 1 might increase slightly, thereby causing an increase of E_g and a consequent increase of I. Since the current flows through the series field of the machine, the increase in its value will cause an increase in the series-field excitation and a corresponding increase in the combined shunt- and series-field strength. The generated voltage will therefore be further increased, causing a yet greater current to flow with the effect of again increasing the field strength and in turn the current. It will be seen that the action is cumulative; that is, that, once started, it will continue unchecked. Just how far it will proceed depends upon the amount of overcompounding.

Before considering what the ultimate result would be, we will turn our attention to the other machine, No. 2, and determine what effect the action of No. 1 has upon it. When the current delivered by No. 1 increases, that of No. 2 must decrease, since the load L remains practically unchanged. The effect of a decrease in current of No. 2 is exactly the reverse of what an increase would have as described in the case of No. 1; that is, the initial decrease would cause a diminution of excitation which would further reduce the current delivered, again affecting the field strength, and so on until some limiting value was reached. To find what this would be, we will consider the joint action of the machines.

We have seen from the foregoing that the current delivered by one machine increases while that of the other decreases. This action will continue until No. 1 carries the entire load and No. 2 carries none. Generally, the action does not cease here, but proceeds until No. 2 is running as a motor driven by No. 1; that is, it takes current from the line instead of delivering its share to it. The direction of the current through its armature would consequently be reversed and therefore that through its series field.

The shunt-field current would, however, continue to flow in the same direction as before, since the field remains connected to the mains as before. The two fields would thus be opposed to each other, with the shunt field predominating at the time the series field begins to reverse. The total field strength will of course be less than that due to the shunt field alone, which will tend to make the machine speed up since it is running as a motor. It is, however, connected to its prime mover whose speed generally cannot be accelerated, and the motor is therefore compelled to run at the same speed as before even though its field be weaker. The counter-em.f. is therefore reduced, which increases the current, since it was found when studying motors that $I = \frac{E - E_c}{R}$, where I is the armature current, E the impressed voltage, E_c the counter-e.m.f., and R the armature resistance. This increase in current increases the series-field current, thereby causing a still weaker field and a consequent further increase in current. The action would continue until the current

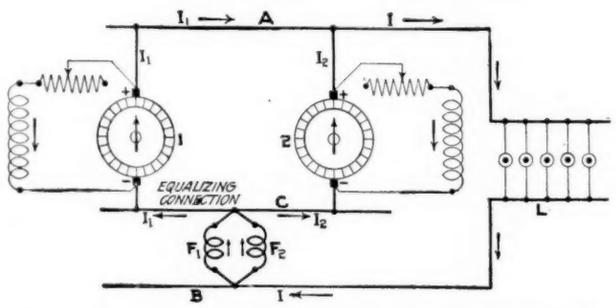


FIG. 7. MODIFICATION OF DIAGRAM FOR PARALLEL CONNECTION OF COMPOUND GENERATORS TO EXPLAIN OPERATION OF EQUALIZING CONNECTION

became so great that the safety devices protecting it from excessive current would operate.

In practice it is found that the sequence of events enumerated in the foregoing takes place in a very short period of time; in fact, the action gives the impression of being an instantaneous one. No sooner has the incoming machine been connected to the mains than the circuit-breakers open. Often the instantaneous rush of current is so rapid that before the circuit-breakers can interrupt its flow it has become so great that its effect in flowing through the series field is to cause the series-field excitation to exceed that of the shunt field and consequently reverse the direction of the mag-

netic field. It would then be found that, when the machine was again started, its voltage would build up in the opposite direction to that it previously had.

Should the safety devices fail to operate before the polarity was reversed, the machine would be converted back from a motor into a generator that would be in series with the other one. The overload would be still further aggravated thereby, and only the operation of the circuit-breakers could save the machines from serious damage. In the case of generators that are only very slightly overcompounded the action would not occur with the same rapidity as in more heavily overcompounded ones; in flat-compounded, and more particularly in undercompounded and in straight shunt generators, as previously stated, there would be no such disturbances at all.

We will now go back to the subject of the equalizing connection previously referred to, show what is meant by the term, and how the connection functions in preventing the disturbances which would occur if an attempt were made to operate overcompounded generators in parallel without using it. As indicated in Fig. 6, the equalizer is a connection between the terminals *ab* of the machines. With switch *s* open they would not operate satisfactorily, but with it closed the equalizing connection would be established and the machines would then operate together successfully. The connection must always be between the junction points of the armature and series field. That is, it could not be made between *c* and *d*, for example, nor *c* and *b*, nor *a* and *d*. Moreover, it must be of a very low resistance—so low that it shall be equal to only a fraction of that of the series-field wind. Since the latter is itself small, that of the equalizer will be negligible for all ordinary values of current. In fact, the connection is usually a busbar of heavy copper similar to the other main connections to and on the switchboard. To more clearly understand the principle involved, reference will be made to Fig. 7, which duplicates the connections of Fig. 6, but shows a slightly different location of the series fields.

Suppose F_1 to be the field of machine No. 1 and F_2 that of machine No. 2, and that their resistances are R_1 and R_2 respectively. Also assume that the currents delivered by them are I_1 and I_2 and that the total current $I_1 + I_2$ is equal to I. Part of this current would have to pass through F_1 and part through F_2, the division depending on the resistances R_1 and R_2. If the generators are of like design and capacity, their field windings would have the same resistance: that is, we would have $R_1 = R_2$. Under such circumstances the current would have to divide between them equally and each would therefore carry $\frac{I}{2}$ amperes.

This would hold true irrespective of what values I_1 and I_2 might have. For example, they might be equal—let us say they have a value of 50 amperes; then the currents through F_1 and F_2 would also be 50 amperes. Again, they might have values of 30 amperes and 60 amperes respectively, which would give $I = 60 + 30 = 90$ amperes; this current would also divide between F_1 and F_2 equally, and each would be carrying $\frac{90}{2} = 45$ amperes. The point to be emphasized is that when an equalizing connection is used the currents through the series fields are not equal to the armature currents, so that a change in armature current does not affect the excitation of the generator. The equalizing connection thus insures the maintenance of the same series-field excitation in both generators under all conditions and consequently prevents the unbalancing of their loads which is otherwise found to occur.

The conditions are not changed by moving F_1 to the left of the diagram and F_2 to the right, until they occupy the positions they have in Fig. 6, since the resistance of the equalizer is very small and does not change the distribution of current. That is, there is a certain voltage drop between *B* and *C* equal to *IR*, where *R* is the combined resistance of F_1 and F_2, and since this voltage exists across both of them, the total current will always divide between them inversely as their ratio. On the other hand, if the equalizer had an appreciable resistance, there would be a drop in voltage between the junctions *ab* when current flowed through the equalizer, and consequently the voltage across *ah* would not be the same as that across *bk*, which is the case when the resistance of the equalizer is negligible.

The current through the equalizer will be equal to half the difference of the load currents. Thus, if I_e is the equalizer current, we have $I_e = \frac{I_1 - I_2}{2}$. A numerical example will show why this must be so. Suppose I_1 to be 30 amperes and I_2 to be 20 amperes. Then the current through each series field will be $\frac{I_1 + I_2}{2} = \frac{20+30}{2} = 25$ amperes, from which it will be seen that the current through armature No. 1 is 5 amperes greater than the current through its field F_1, and that the current through armature No. 2 is 5 amperes less than that through F_2. The excess current of F_2 flows through the equalizer to the junction *a* and thence through the armature of generator No. 1, thereby supplementing the current from F_1 and making up the deficiency in it. The equalizer current is seen to be one-half of the difference between the armature currents, as predicted, since we have $I_1 - I_2 = 30 - 20 = 10$ amperes, and $I_e = \frac{I_1 - I_2}{2} = \frac{10}{2} = 5$ amperes.

In the next lesson we shall inquire into the reason for the satisfactory operation of shunt generators when connected in parallel as contrasted with the behavior of compound ones when no equalizer is used. Practical points in reference to methods of connecting and operating generators for parallel service will also be discussed.

The problem given in the preceding lesson was to find the efficiency of 10-hp. 220-volt shunt motor at 25, 50, 75, 100 and 125 per cent. of full-load current. The normal current was given as 38 amperes, the armature resistance as 0.3 ohm, the field current as 1.0 ampere and the constant losses as 400 watts. Applying the

DATA DERIVED IN COMPUTING THE EFFICIENCY OF A 10-HP. 220-VOLT SHUNT MOTOR

I_t	E	$I_a = I_t - I_f$	$I^2_a R_a$	$L = K + I^2_a R_a$	$W = EI_t$	$\epsilon = \frac{W-L}{W}$
Amperes	Volts	Amperes	Watts	Watts	Watts	Per Cent.
9.5	220	8.5	22	422	2,090	79.8
19.0	220	18.0	97	497	4,180	88.1
28.5	220	27.5	227	697	6,270	88.9
38.0	220	37.0	411	811	8,360	90.3
47.5	220	46.5	649	1,049	10,450	90.0

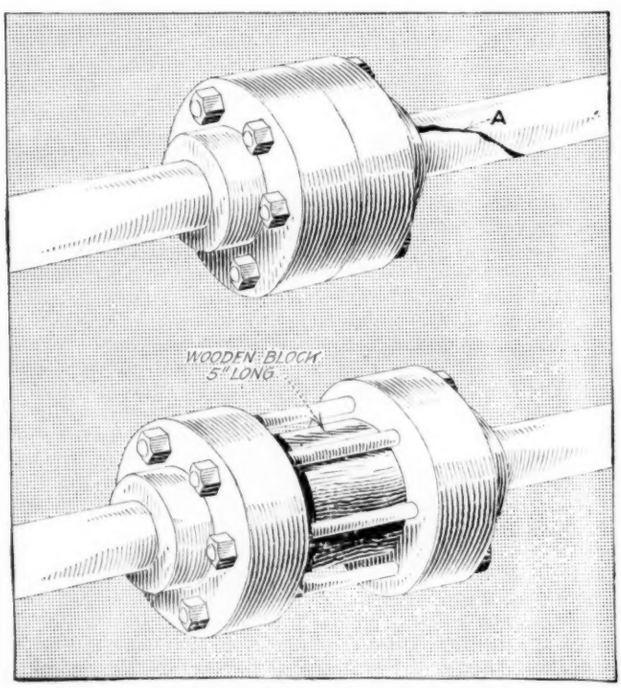
symbols used in the preceding lesson, we have the results shown in the table. The various load currents specified are represented by I_t, and the normal voltage by E. The armature currents I_a are obtained by subtracting the field current I_f, which is given as 1.0 ampere, from the values of I_t. The variable losses are equal to $I^2_a R_a$, where R_a is the armature resistance, which is given as 0.3 ohm. The total losses L are the sums of the variable losses $I^2_a R_a$ and the constant loss K, which latter is given as being 400 watts. The inputs W are obtained from the multiplication of the values of I_t by the normal voltage E. The efficiencies are then computed by dividing the inputs by the outputs, that is, dividing $W - L$ by W.

What currents would the generators whose external characteristics are represented in Fig. 1 deliver if their terminal voltage were 110 volts? What positions would the curves have to occupy if the generators were required to supply equal parts of a load of 100 amperes at 120 volts?

Emergency Shaft Repair

A shaft broke at a coupling *A*, and instead of using another coupling and a new piece of shafting, a piece 5 in. long was cut from the defective end and the new end turned on the remaining length of shafting on which to fit the coupling.

Next a round piece of tough oak wood, 5 in. long and of a diameter to fit inside of the bolt holes of the coupling was secured, as were also bolts 5 in.



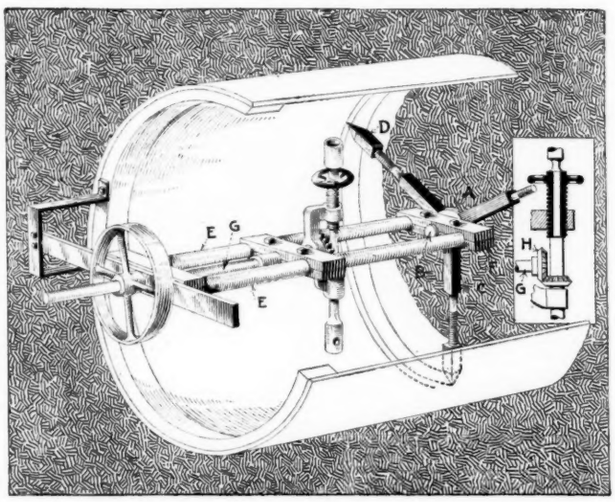
WHERE THE SHAFT CRACKED AND HOW IT WAS REPAIRED

longer than those originally used in the coupling. All was assembled as shown in the lower view.

This job was completed inside of an hour and gave satisfactory results. The wooden block held without turning, the bolts being drawn up tight.

A Special Drilling Device

The illustration shows a device that has been found of advantage when it is necessary to drill a hole from the inside of a boiler or tank, says J. A. Lucas in *Coal Age*. *A* represents a base piece made with a journal stud *B*. This base piece is provided with a radial arm



DETAILS OF A SPECIAL DRILLING DEVICE

C, with threaded ends and nuts made with conical projecting ends, as shown at *D*. One of these pieces is used at each end of the machine, when convenient, for entering and holding the frame. When not convenient to use two of them, one end of the frame is sustained as shown in the illustration or in some other manner that may suggest itself.

The casting *F* is made of two pieces and is provided with a bearing for the pin *B* and holds the ends of the rods *EE*. The actuating shaft *G* carries the bevel gear *H*, more clearly seen in the figure at the side, which drives the drill spindle, whose ends are of different lengths for convenience in reaching to different distances. The crosshead may be slid along as required on the rods and the revolving frame and the drill turned around to different positions.

Large Pumping Stations in Holland

With a view to increasing the amount of land under cultivation, several large pumping stations for unwatering inundated, or water-logged polders, are being erected in Holland, says the *Engineer*. Another large pumping station is about to be erected at Lammerburen, in the province of Groningen, where it will be used for reclaiming the polder "Electra."

This plant will be the largest electrically driven pumping installation in Holland if not in Europe, and will comprise three screw-pumps similar to those used for the City of New Orleans, each pump being driven by a three-phase motor of 558 hp. capacity and capable of delivering 210,000 gal. per min. The three pumps together, therefore, will lift 630,000 gal. per min., or at the rate of over 900,000,000 gal. per day.

It may not be necessary for a steam-engine operator to be well versed in the theory of heat motors, but he misses a lot of solid satisfaction if he lacks that knowledge.

EDITORIALS

Morale in the Power Plant

ONE of the lessons of the war which should be carried over into the new year in power-plant practice is the value of morale. There is not much room for argument at this late day regarding the value of teamplay in industrial organizations as well as in military and naval enterprises. Morale, however, is more than coöperation; it represents the spirit of the attack upon the problem in hand or the work to be done, and is greatly needed in the reconstruction era into which the world has now entered.

The power plant is unusually well situated to take advantage of the results of morale. It is an organized affair in which orderly processes are conducted toward specific useful ends. The results attained from shift to shift or from day to day furnish an index of efficiency which should be the point of departure for the next cycle's operations. The work of the plant is closely related to industrial or other time schedules, and so the conditions are favorable for both self-discipline and high-grade executive supervision.

The successful development of morale rests upon a common objective recognized by the rank and file of the organization. While the great struggle abroad was on, this objective was the clear-cut duty of winning the war. Everything else had to be subordinated to this. Power-plant operation took on the glow of patriotic service; fuel saving became a part of the nation's tactics. Overtime was cheerfully accepted and labor shortage was acknowledged without complaint by those who filled the breach. Now the war is won and as we turn the corner of the year are motives still with us capable of leading us along the paths of efficiency, or are we going to slump back into the old days of wasting resources and being satisfied to "get by" with a certain mediocre performance in place of the superlative services rendered in the last few months and years?

The responsibility is dual. The employer, the power-plant owner, the superintendent, must see to it that a new incentive is provided and maintained for his men to "carry on," sharing in some manner the increases in efficiency secured by the staff. The old days of hiring two or three engineers and a bunch of firemen at the lowest possible wages and turning them loose in the station without subsequent regard to any ratio between pay and plant performance do not "jibe" with 1919 conceptions of justice or of good business. The days are passing when any power-plant owner has any reason to expect to "hog" all the savings made by the men who run his station; and in their place are coming days where a measure of reward for extra effort will be accorded those responsible for the improved results. And the employee—well, the time has come for him to face the everlasting fact that hard work and hard work alone must furnish the basis of all prosperity; that merely "getting by" is not the way to advance the fortunes of oneself or one's employer; and that to share in the profits one must deserve them. Thus there is a call for a new and high kind of morale, expressed in faithful industry, initiative and fair dealing for the recognition of common interests by employer and employee. With individual determination to make 1919 set a new standard in relations between plant owners and plant operators, gains in efficiency will be realized which will be mutually and nationally helpful, and something of the spirit of the fighting men of 1918 will be seen in the assault of the plant owners and workers upon preventable wastes and other evils of long standing which are now due for the discard.

Liberty Fuel

DURING the last few years the gasoline substitute, through the various nostrums that have been exploited and proclaimed by the daily press, has well earned a place beside the proverbial perpetual-motion machine. In practically all of these cases the man with the "Magic Pill" or the "Green Powder" has claimed what, to the technical man, was the impossible and thus immediately stamped the product as a fake.

These experiences have led the engineering profession to view with skepticism anything of this nature, and it has consequently received the announcement of the new Liberty fuel with the "I am from Missouri" attitude.

There is an essential difference, however, between Liberty fuel and its predecessors; the claims are more conservative and it is freely admitted that the basis of the fuel is kerosene—as high as eighty per cent—the remaining ingredients, which have not been officially disclosed, imparting the necessary "pep" to the kerosene.

The new fuel appears to have been evolved with a view to meeting the predicted shortage of gasoline during the spring of 1919 had the demands of the war continued. Its performance does not differ greatly from that of gasoline and the cost, it is claimed by the inventors, would be slightly less. The tests made at the Bureau of Standards, reproduced in part elsewhere in this issue, do not show marked advantage over a high grade of gasoline, the essential difference being a greater initial explosive effect with resultant higher flame propagation and lower temperature of exhaust gases—an advantage, as concerns a cooler-running engine, provided there are no accompanying detrimental effects.

For reasons involving the rights of the inventors they have not seen fit to disclose the composition of the mixture or the process, but indications point very strongly to the employment of a well-known explosive in small quantity as one of the ingredients. Whether this is in sufficient quantity to produce a detrimental

effect on the metal of the engine by long use under service conditions remains to be proved. It is too early to condemn the fuel, and out of fairness to the inventors, opinion should be reserved. On the other hand, the sooner they come out into the open the sooner will confidence in the product be established. It is significant, however, that, although the tests were conducted at the Bureau of Standards, that Government agency has not yet seen fit officially to give its stamp of approval and the proposition in many respects remains a private one.

"La Ingenieria Internacional"

REALIZING the value of the international exchange of ideas on things engineering, the McGraw-Hill Company on March first will begin publication of a magazine dedicated to that purpose. While eventually it is expected to appear in editions in several languages, the original issue will be in Spanish, under the name, "*La Ingenieria Internacional*," aimed to serve Latin-America and Spain.

The purpose of the new magazine, which has been under consideration for several years, is to afford a medium for the presentation of those developments in American engineering which may be of value to engineers, contractors and manufacturers in other lands. At the same time, following the practice of the present McGraw-Hill publications, a far-flung editorial organization will be developed, so that there will be drawn into the paper the best of engineering practice in Latin-America, Spain and other Spanish-speaking countries. Aside from this function, the new magazine will be an important developer of international goodwill, and at the same time a medium by which American manufacturers engaging in export trades can carry their message to prospective buyers in foreign lands. It may be a cause of surprise that the McGraw-Hill Company, whose specialized papers circulate so widely overseas, should establish a magazine to serve the foreign field. The reason, however, is not hard to find. The present highly specialized papers appeal only to those who are situated where engineering enterprise has made such progress that there is room for the specialist and need for the latest refinement in equipment and design. But everywhere the world over are territories newly developing where the engineer, the contractor and the manufacturer must turn their hands to many lines. It is to serve the general practitioner so situated that the new magazine, and its later companions in other languages, will be started. The specialized papers in English will still hold their place as the recorders of the best in the advanced practice of American engineering.

Pointers on the Care of Equipment

THE letter on another page of this issue, describing the difficulties the contributor at first experienced in operating an indirect automatically controlled heating system is proof, if proof be needed, of the soundness of the stand *Power* has always taken—that it is to the mutual advantage of both manufacturer and user to publish complete and intimate description of all equipment and full instructions for its care and management, together with suggestions as to things to "watch out for."

It can be acknowledged by anyone that his apparatus is not foolproof without detracting in the least from its merit. A thermostat, for example, is a delicate instrument, and it is often mistreated or neglected simply because the man in charge of it does not realize its delicacy. An exceedingly small air leak or particle of scale may cause it to fail to function properly. Why not caution the engineer against such things? The user of an electric motor may get along first rate without knowing the kind of winding on the armature, but knowing its construction thoroughly, he will no doubt take more interest in his machine.

It is safe to say that many good systems of heat control have failed and become discredited simply because there was little or nothing done by the manufacturer or dealer to "wise up" the user of the equipment. *Power* stands ready to entertain such articles for the benefit of all.

A Series of Articles on the Diesel Engine

CONSIDERABLE impetus has been given to the Diesel-engine industry in the United States by the adoption of Diesel engines for the propulsion of a large number of ocean-going vessels of various types built during the war. The same type of engine has also been installed on many vessels as a source of power for driving lighting outfits to be used in emergencies. The result has been to focus attention on the Diesel engine as a prime mover.

In this issue is the first of a series of twenty articles dealing with the details of construction and operation of stationary Diesel engines. They are written in the form of informal talks between the chief engineer of a Diesel-engine plant and his associates, and so they naturally lead to friendly discussion of the troubles met with in the management of the engines and the methods used to overcome the difficulties.

Lieutenant Morrison, author of the articles, has had an extensive and varied experience in erecting and operating oil engines, particularly in the Southwest, and so he writes from first-hand knowledge of the subject. Regular readers of *Power* will recall his recent series of contributions on the low-compression oil engine. The new series is equally informative and will be of value to all who are interested in the Diesel engine.

Failure has brought success in many instances. The Allied army failed to decisively defeat the German army for over three years, but where is the German army today? Westinghouse could not find a market for his air-brake when it was first perfected, but look at it now. The Panama Canal was a failure under several managements, but Uncle Sam finished the job. Moral: If one effort is a failure, it does not mean that the situation is hopeless. Tackle it again!

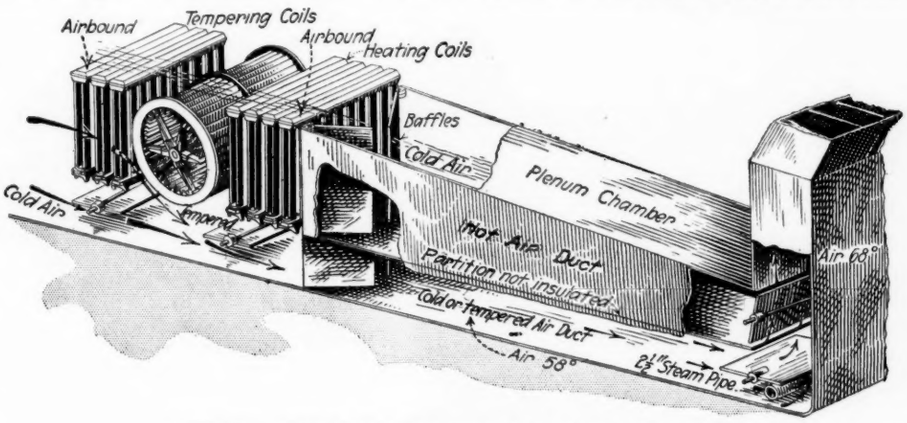
Since the Fuel Administration became active in its investigation of steam plants, many an engineer has discovered that daily plant records are just as interesting as box scores and batting averages, and considerably more important.

CORRESPONDENCE

Experience With Automatic Indirect Heating System

Following is the story of some of the troubles we had with an automatically controlled indirect heating system in a public school. Being unfamiliar with this particular system of control at the time, I called on a representative of the company and was given many good pointers and among other things was told that every system, even of the same make, has its own peculiarities of operation. That this is true I found out before the heating season had progressed very far.

The first "snag" that we struck was that we could not heat the whole building at once. One half would not heat until the other half was up to temperature and the thermostats had closed half the dampers in the plenum chamber; in fact, one half of the building would actually get colder while the other part was being heated. As the time for heating the rooms was unreasonably lengthened by this, I began to hunt high and low for the trouble, and I found that, on very cold days especially, the heating coils would heat only halfway across. Raising the pressure to 15 or 20 lb. did no good. The steam supply was of ample capacity and the manifolds, top and bottom, were large, but the air vents or valves were located on the wrong side of the radiators, allowing them to become airbound, and of course the air passing at that side was not heated. We could not change the location of the valves during the heating season, but improved the operation greatly by installing baffles in the plenum and tempered-air chambers in such a way as to mix the air to a uniform temperature, after which we had no trouble in raising the temperature evenly throughout the building. We will have the vents changed in the spring.



GENERAL ARRANGEMENT OF COILS, FAN AND DUCTS

In mild weather the building was overheated because the thermostat in the tempered-air chamber was located about midway of the length of the tempered-air duct instead of at the extreme end, so we had to keep the thermostat set for a low temperature (58 deg.) at this point because the temperature was increased another 10 deg. in passing to the end of the duct, partly because of the partition between the two chambers, the tempered-air and hot-air duct not being insulated. An uncovered 2½-in. live steam pipe in the tempered-air duct also tended to raise the temperature still more. To "get next" to such peculiarities takes time, and in the interval someone has to suffer inconvenience. In many instances a perfectly good system of heat control is condemned because of defective installation and improper operation of the apparatus.

A. BLOM.

Charleston, Ill.

Making Diesel Operators from Steam Engineers

On page 816 of the issue of Dec. 3, 1918, I notice an editorial on "Making Diesel Operators from Steam Engineers." This article was written on suspicion, apparently, and it might have been a good thing to have had the suspicion verified first. In regard to the difficulties of operation I would like to call to your attention the fact that the cylinders in a Ford automobile have very much nearer the temperature and pressure conditions in a Diesel engine than they have to those obtaining in an ordinary, reciprocating steam engine. Have you ever heard it asserted that a Ford automobile needed an extraordinarily skilled attendant, due to these pressures and temperatures? I never have, and I don't believe anyone else has. As for the running clearance of the pistons in the liners, Diesel engines have two or three times the clearance that a good many of our steam engines had.

The ideal engineer to have charge of a Diesel-engine installation is one that is a good executive to see that his force is properly organized and that the various things that have to be done are actually done from time to time.

This, you will notice, is the same kind of man who should have charge of any machinery. The Diesel engine and the things that have to be done can easily be understood and learned by any operator of intelligence. Special skill is not required, and if he will see that these things are done from time to time he is no more likely to have trouble with a Diesel engine than with any other kind of engine. In fact, the things to do to operate a Diesel engine properly call for less skill and are much easier to learn than the things necessary

to properly operate a steam plant. We have become so familiar with the steam plant, however, that the skill necessary for its proper operation is taken as a matter of course.

HARTE COOKE,
Auburn, N. Y. McIntosh & Seymour Corporation.

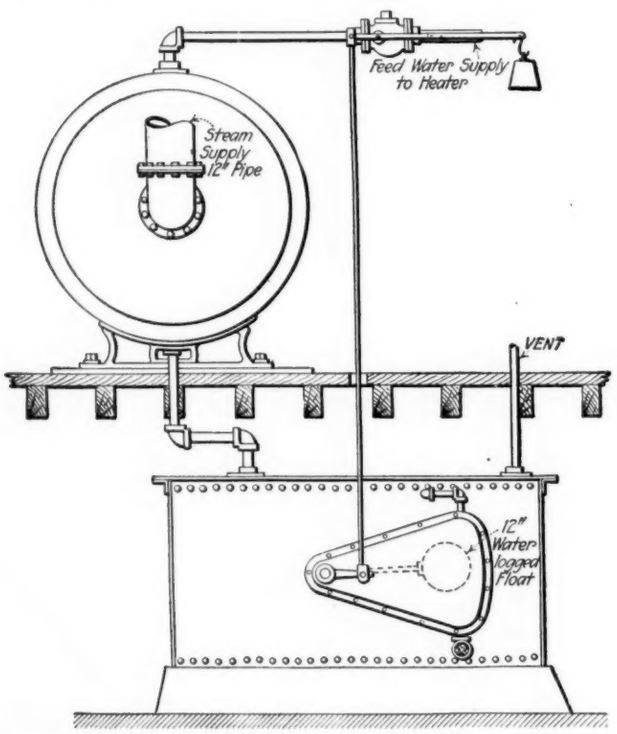
Speculation Regarding a Boiler Explosion

In the issue of Nov. 26, 1918, page 776, there appears an account of a boiler explosion, accompanied by a chart from a recording gage, upon which I wish to comment. There was a sharp rise in pressure from 6 to 6:20 a.m. due to the breaking up of the banked fire. At this time it was doubtless discovered that the water was low, and starting the pump and closing the draft caused a decided drop—to about 40 lb. Then it was decided to pull the fire, the steam holding up well during this period, but it afterward went down very rapidly to about 5 lb. At this time the water coming in contact with the hot plates turned it into a flash boiler, causing the pressure to rise so rapidly as to show instantaneous rise on the chart to 120 lb. at 10 minutes to 8 o'clock, at which time the explosion took place. It is well known that a high pressure can be obtained in a few minutes with flash boilers. This makes them dangerous and prevents them from coming into general use.

Spokane, Wash. WILLIS W. NELSON.

Floatless Floats

A 12-in. copper float, connected to a valve in the water-supply pipe to our open feed-water heater, filled with water, sank to the bottom and remained there,



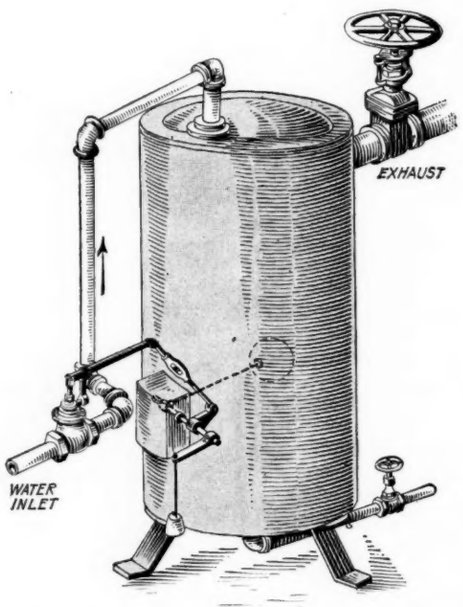
COUNTERWEIGHT BALANCES FLOAT WHEN IN WATER

"dead." Acting on the well-established principle that it is a bad habit to spend money, the chief refused to order a new one. A lever, with a counterweight, was bolted to the valve arm, which raised the float to the surface of the water, converting a buoyant float into a simple displacement body. A buoyant float exerts force to rise to the surface, while a displacement body exerts its greatest force in an opposite direction when not in water, because of its weight. I think this type of float can be used to advantage in many places and do away with the annoyance that is almost sure to occur sooner or later with any buoyant float. The illustration only suggests how to apply this principle in a simple and practical way.

In our case this arrangement is now working nicely, is positive in action and is certainly troubleproof.

Milford, N. J. GEORGE WOOLAVER.

For some time the float in our heater had a leak, and it would not rise and shut off the water. The heater would fill until the water ran out at the overflow,



LOGGED FLOAT HELD UP BY OUTSIDE WEIGHT

and sometimes if the load was light the water would get into the exhaust pipe. What we need, of course, is a new float, but that costs money and it is quite a job to take the heater apart. To tide over, I made a clamp and fastened it to the rod that the float is connected to and hung weights on the end of the clamp, acting in the opposite direction, to balance the extra weight of the float. The float is now held partly out of the water, and as the water recedes the weight of the float overbalances the outside weight, closing the valve, and the water is held at the right height in the heater.

JOHN W. WARWICK.
Salt Lake City, Utah.

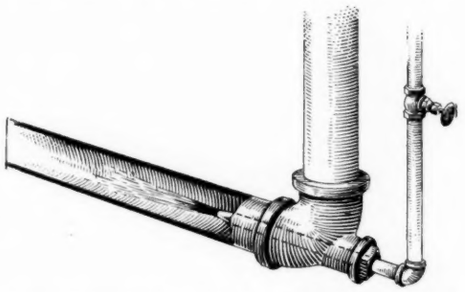
[By a curious coincidence the foregoing two letters on the same subject reached us at almost the same time.—Editor.]

Utilizing Waste Exhaust Steam

We have two separate heating systems in which exhaust steam is used. Into one of them more exhaust is discharged than can be utilized, and some of it was formerly allowed to escape to the atmosphere; but into

the other there is not enough discharged to supply the demand, so that live steam at low pressure had to be admitted through a reducing valve.

I have connected these systems and steam flows from one to the other. To overcome the friction in the pipe and increase the flow of steam a "siphon" was added.



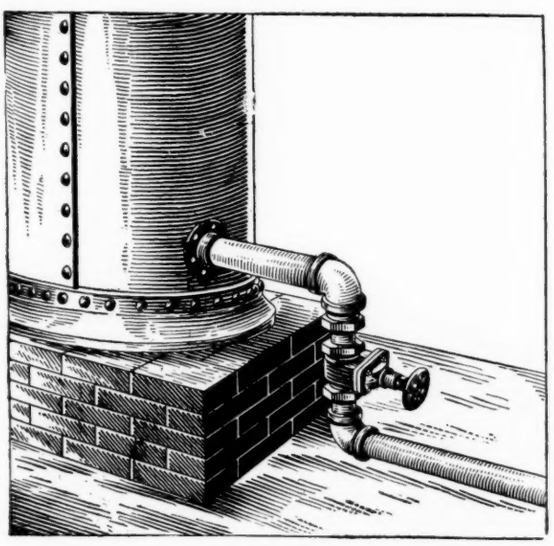
HIGH-PRESSURE JET IN HEATING SYSTEM

This draws steam from one system and discharges it into the other, giving satisfactory results. The high-pressure steam pipe is only ⅜-in. with a ¼-in. nozzle, hence it cannot use as much high-pressure (75-lb.) steam, and since it is discharged into the heating system it is not wasted. W. H. WAKEMAN.

New Haven, Conn.

A Dangerous Blowoff Connection

A large vertical boiler was installed with the blowoff piping made up as shown in the illustration. The opening in the shell was for 2½-in. pipe, and on the end of the first nipple used was a regular 2½-in. elbow with a 2½ x 2-in. bushing in its lower end. Then



BUSHING USED TO MAKE UP BLOWOFF PIPING

followed a 2-in. nipple and one of the poorest gate valves on the market. This valve might have lasted a few months, but the light cast-iron bushing was the weakest point in the line, as it reduced but one pipe size and was plainly too weak to be used in connection with 150 lb. pressure. Furthermore, it was not screwed into the elbow enough to take up all the threads.

When the boiler inspector made his first visit, this piping was condemned and taken out, thus preventing what would probably be called an "accident" in case of a failure. The specifications and the blueprint for this piping called for a reducing elbow, thus dispensing with a bushing at this point. Notwithstanding this, the job was done as shown. W. W. HENRY.

New Haven, Conn.

Boiler Blowoff Valves

The letters about blowoff valves are getting interesting and demonstrate that too much care cannot be used in dealing with this part of the boiler equipment.

A regular overhauling or inspection of the blowoff valves at least once a month should inform one of the condition of the valves, and it would be impossible for the bolts to rust through between inspections, even though they are subject to salt water, dampness from blowing back of exhaust steam, leaky tubes, and soot or flue ashes from cleaning the boilers, and combustion chambers. The type of fittings also plays an important part. Some use screwed valves and fittings rather than flanged ones because they are a little cheaper, but this is bad practice. The space in back of boilers is usually limited and crowded with connections, besides being dirty and wet while cleaning the boilers, especially those of the water-tube type. The blowoff must be connected to the lowest part of the boiler and is therefore usually close to the floor. Under these conditions a man grinding or repairing the valve will seldom do the best work. He is anxious to get the job done as soon as possible, but if flanged valves or stop-cocks are used they may be taken out in a few minutes and the grinding and repairs attended to on a bench where it can be well done and the valves examined both inside and outside.

These two points, frequent examination and the use of flanged fittings, will prevent a great deal of trouble and give men confidence in the safety of the blowoff piping. I agree that a stop-cock having the plug held in place by a substantial gland or guard is the only kind that is safe. F. C. HEYLMAN.

Martinez, Calif.

In various issues of *Power* I have noticed that when a blowoff cock is illustrated, the old style, open top and bottom, is invariably shown. Inasmuch as this type is practically obsolete and in fact its use prohibited by law in some states, it seems that an up-to-date type should be shown instead. L. C. COOMBS.

Louisville, Ky.

Unsymmetrical Indicator Diagrams

Commenting on "Unsymmetrical Indicator Diagrams," by J. Lewis in the issue of Dec. 10, page 856, I do not understand how he could increase the compression effect by increasing the compression on two ends of the two cylinders by robbing the opposite two ends. With the compression about equally divided between both ends of each cylinder, the compression presure per square inch of piston area would be as great as the pressure indicated by the diagram, and would be much better steam distribution.

By observation (that is, without measuring) the areas of the crank and head ends of both diagrams appear to

be about equal. This being the case, if the valves were moved so as to cause about equal compression on both ends of the cylinders, the points of admission and cut-off would be greatly changed, increasing the area of one end of the diagram over the other. [The diagrams shown were simply to illustrate the point.—Editor.]

I gather from the letter that the engine had a piston or Sweet, or similar type of valve. Therefore, to increase the compression either an offset shaft key in the governor wheel, so as to advance the governor wheel, or an offset (that is, eccentric) governor rod pin should be installed in the governor instead of the concentric pin. This would advance the valve travel in relation to the crank, giving an earlier steam admission, which would help out on the compression. It would also diminish the maximum cutoff of the steam admission, but not enough to prevent the engine from carrying a good overload if the diagrams as shown were taken at about full or average load.

Two wrongs in this case do not make one right.

San Francisco, Calif. V. R. HUGHES.

Combating Boiler-Tube Failures

The following is an account of the method used in combating the tube failure in 14 water-tube boilers totaling 6200 hp., the trouble being due to scale. The operation and maintenance of the boiler plant rested upon a foreman. As the job had frequently changed hands, no boiler-maintenance records of any value were available, but as the output of the plant increased and the shortage of labor became more acute daily, the present foreman found himself up against it.

Instead of starting at the end of the boiler house and going down the line, cleaning each boiler completely regardless of the actual hours it had been in service, a record was kept of the time each unit was in operation and the one showing the most hours was cleaned first. This did not help matters to any great extent, but it did show that when a boiler had reached 600 hours of service without being cleaned, tube trouble could be expected, which was taken care of as follows:

After about 500 hours of service, six rows of tubes only were turbined each time—the two bottom rows and four others. For instance, at the end of one period the two bottom rows and the third, fourth, fifth and sixth from the bottom would be cleaned and at the end of the next period, the two bottom rows and the seventh, eighth, ninth and tenth rows from the bottom. This method helped considerably, and where formerly the replacement of one tube a day was getting to be the rule, we now renew about one a month.

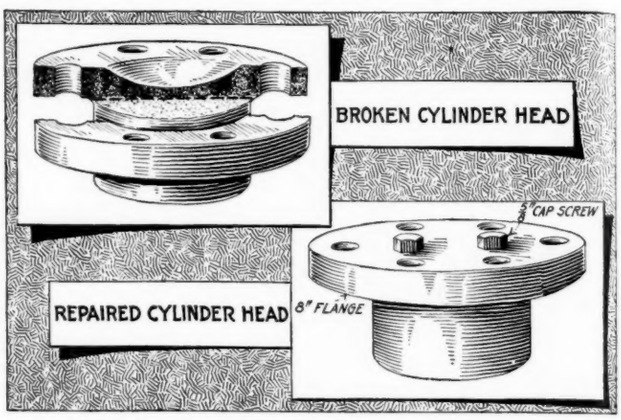
With the aid of a draft gage, Orsat and steam-flow meter furnace-cleaning periods were also established, as were periods for cleaning the waterbacks, etc. These latter periods were more flexible and were stretched or shortened occasionally to fall in with a cleaning period and thereby eliminate needless shutting down of a boiler.

I might mention a few other arrangements that helped a great deal, such as the use of a turbine tube cleaner that left a clear tube before it would pass through; rigging up the hose so that one man could handle a cleaner; using a slice bar with a wide blade and keeping it sharp; and last but not least using the Orsat, draft gage and flow meter to determine as far as possible the best firing conditions and instructing the fireman accordingly, also staying with him enough to see that he did his work. A. ENGELLAND.

Joliet, Ill.

Broken Cylinder Head Repair

The head blew out of a 5 x 5-in. steam cylinder operating a stoker, at about 1 o'clock p.m. and as the stoker was needed for the evening load coming on about 4:30, I made a temporary repair as follows: I chipped the broken head along the line shown dotted, keeping depth measurement as near as possible to that of the original head, and secured this hub part to an 8-in.



BLANK FLANGE IN PLACE OF CYLINDER HEAD

blank flange, which happened to be the right size, with two ⅝-in. capscrews, as shown in the illustration. The job took three hours and the stoker was ready in time.

Trenton, N. J. JOHN T. LOCKETT.

Valves Do Not Wear Well

A pump handling the returns from a vacuum heating system was fitted with old hard-rubber valves that were in bad condition, being tapered at the edges. As new ones had not arrived at the beginning of the heating season, the old ones were dressed down by using sandpaper and then they were ground to a fit on the valve seats, using common grinding compound. The result was pleasing, but as the material was too brittle, soft valves were used, which give better results while they last, but are not expected to last as long as hard rubber valves, which in my case is about two weeks.

The returns vary from 60 to about 180 deg. F., and with these temperatures hard-rubber valves break where the studs come in contact with them; in some instances they break in small pieces. Some of the valves have holes on the lower side that resemble burst blisters, but there are none on the upper side.

It appears from the foregoing that something is wrong with the kind of valve used. Who can suggest a remedy for the short life of these valves? M. C. LARSEN.

Omaha, Neb.

Development of the coal resources of Alaska, which has been reported as locked up by Federal laws, has been greater in 1918 than in all previous years. Alaska anthracite is now being sold in Seattle.

INQUIRIES OF GENERAL INTEREST

Safety Valve for Double-Grate Down-Draft Boiler—In selecting the size of a safety valve in accordance with the size of grate, how should the grate area be estimated for a double-grate down-draft boiler? B. R.

Where a boiler is provided with a double grate for down-draft combustion, the grate area taken for estimating the size of safety valve should be the area of the lower grate plus one-quarter of the area of the upper grate.

Pitch of Rivets of Girth Seams—Why is the pitch of rivets on girth seams of horizontal return-tubular boilers generally made less than in the longitudinal seams? W. P.

The outer plate in a girth seam is more or less overheated where the seam passes over the fire, and there is a tendency for the outer plate to expand away from the inner one, resulting in leakage. For this reason the space between rivets is made smaller than on cool seams of the boiler.

Heat of Combustion of Various Fuels—What quantity of heat is developed by combustion of fuel oil, coal, natural gas, carbon, hydrogen and acetylene gas? N. C. D.

The heat of combustion of fuel oil, coal and natural gas depends on their analyses. The heat of combustion of fuel oils varies from 18,000 to 20,000 B.t.u. per lb.; commercial coal from 10,000 to 14,000 B.t.u. per lb.; natural gas about 1000 B.t.u. per cu.ft. The heat of perfect combustion of pure carbon is about 14,500 B.t.u. per lb.; perfect combustion of hydrogen in air 50,000 to 60,000 B.t.u. per lb. and acetylene in perfect combustion, with oxygen, 1685 B.t.u. per cubic foot.

Improving Flexibility of Leather Belting—What is the best method of improving the flexibility of a new leather belt; is not mineral oil good for the purpose? W. K. S.

Mineral oil is a solvent of albuminous substances and therefore is detrimental to the natural cementing substance of leather. For improvement of the flexibility, remove the glaze from both sides of the belt with a damp cloth and give both sides a liberal coat of lukewarm neatsfoot oil, rubbed off dry after standing 10 to 12 hours. A new leather belt should be thus treated several times a month and afterward kept moderately "stuffed" with the oil to prevent stretching and cracking from alternate absorption of moisture and drying out with changing conditions of the atmosphere.

Obtaining Additional Compression on Corliss Engine—On a Corliss engine with two eccentrics, should increase of compression be obtained by changing the length of the exhaust-valve rods or by advancing the exhaust eccentric? W. K. R.

It is better to obtain additional compression by advancing the exhaust eccentric rather than undertake to preserve pressure of expansion near the end of the stroke where it is of little value. If the cutoff is short, earlier release may be of benefit in preventing the valves from slamming on account of the pressure being carried below the back pressure, while with a heavy load it always is desirable to have release early enough for the cylinder to be cleared of steam previous to the return stroke.

Form of Chimney Flues—Why are smoke-stacks made larger at the bottom than at the top? E. E. R.

Brick chimneys and self-sustaining steel stacks are generally made larger at the bottom to increase their stability against wind pressure and sometimes only for architectural effect. On account of loss of temperature of the gases in their ascent through a chimney flue, they are somewhat denser at the top of the chimney, and enlargement of the flue at the bottom may have some advantage in obtaining greater uniformity of velocity of the gases. But for chimney flues of ordinary proportions, such an advantage is negligible and the draft capacity may be considered as equivalent to that of a flue of uniform size and of cross-section equal to the smallest part.

Relations of Currents in A. C. Systems—For transmitting a like amount of power at the same voltage and power factor, what would be the value of the current in each of the following systems: (a) single-phase, (b) four-wire two-phase, (c) three-wire two-phase, (d) three-wire three-phase, and (e) four-wire three-phase? W. D. T.

If I is the current in amperes, W the power in watts, E the voltage, and $P.F.$ the power factor, we would have (a) $I_a = \frac{W}{E \times P.F.}$; (b) $I_b = \frac{I_a}{2}$; (c) in the two outside wires $I_c = I_b$ and in the common wire $I_c = \sqrt{2}\, I_b$; (d) $I_d = \frac{I_a}{\sqrt{3}}$; and (e) in the three outside wires $I_e = \frac{I_a}{\sqrt{3}}$; and in the common wire $I_e = 0$. The foregoing conditions are true on the assumption that load is evenly balanced between the phases.

Advantage of Inclined over Vertical Belt Drives—Why will a belt on an angle of about 45 deg. transmit more power than a vertical drive? F. A. S.

When a belt is placed over a pair of pulleys, both sides of the belt may be assumed to have the same tension, but while transmitting power the belt stretches from greater tension on the driving or tight side, which immediately results in less tension on the slack side. When the sides are vertical, as in Fig. 1, the slackening may be sufficient to permit the belt to fall away from the lower pulley as indicated by the dotted line, or at least reduce the pressure and friction between the belt and the face of the lower pulley and this condition is aggravated by the weight of the belt. When the belt is inclined as shown in Fig. 2, increase of tension on the driving side reduces the tension on the slack side. When the lower side AB is the driving or tight side, the slack side, indicated by the dotted line CDE, becomes wrapped around more of the lower pulley; and when the upper side CE is the tight side, the slack side assumes a position like AFB and remains wrapped around nearly as much of the lower pulley. In either case the belt remains supported by the lower pulley and there is assistance of the weight of the belt to produce pressure against the face of the lower pulley. Hence for the same initial tension a belt is capable of transmitting more power than when the drive is vertical.

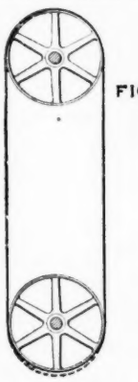


FIG. 1

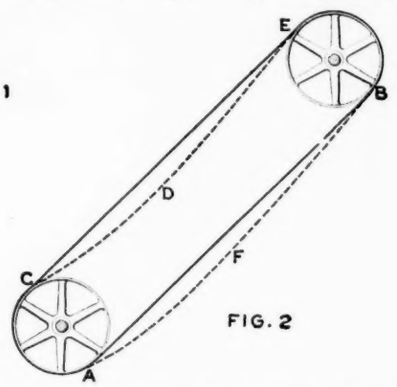


FIG. 2

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary for the inquiries to receive attention.—Editor.]

The Chemical and Physical Control of Boiler Operation*

By E. A. UEHLING

The economical status of a boiler plant can be approximately determined by either the mechanical method, based on the heat utilized, or the chemical and physical method, based on the heat wasted. The author discusses the advantages and disadvantages of both methods and shows that while each is necessary for complete results, the chemical and physical method gives more directly useful information.

THE value of a fuel depends on the heat it contains, and the value of the heat depends on the degree of its utilization. The heat contained in coal is liberated by the chemical process of combustion, hence combustion efficiency is the prime requisite for the economic utilization of fuel. This is especially true in the application of heat to the steam boiler. The economical status of a boiler plant can be ascertained, in a rough, wholesale way, by either of two distinct methods: The mechanical method, based on the heat utilized; or the chemical and physical method, based on the heat wasted. The mechanical method relies on the readings of the coal weigher and the water meter or steam-flow meter. If the heat value of the fuel is known, the data obtained by these appurtenances enable one to calculate roughly what percentage of the heat in the coal is utilized in making steam. For obvious reasons the results cannot be calculated oftener than once a day, and generally once a week is considered sufficient for a control over the operation of the boiler plant. Aside from the lateness in getting the desired information, this method suffers in accuracy and reliability as a control from the following errors and shortcomings: The coal weigher cannot discriminate between coal and ash and moisture, and since these constituents are never constant and frequently vary 5 per cent. or more in successive shipments, and since the heat value of the fuel depends on its purity, the calculated results will be that much in error; the water passed through the meter is not all evaporated, an appreciable amount may be carried over with the steam, more may be lost through leaky blowoff cocks, and considerable is wasted by blowing off the boilers, which is not only not accounted for but actually appears on the credit side; the steam may be superheated; the feed-water temperature may vary appreciably. Thus we see that a water meter and coal weigher can give only a rough, wholesale control, unless supplemented by scientific instruments and observations. The mechanical control has another and even more serious shortcoming in that it gives absolutely no clue as to why the plant as a whole is operating more or less wastefully.

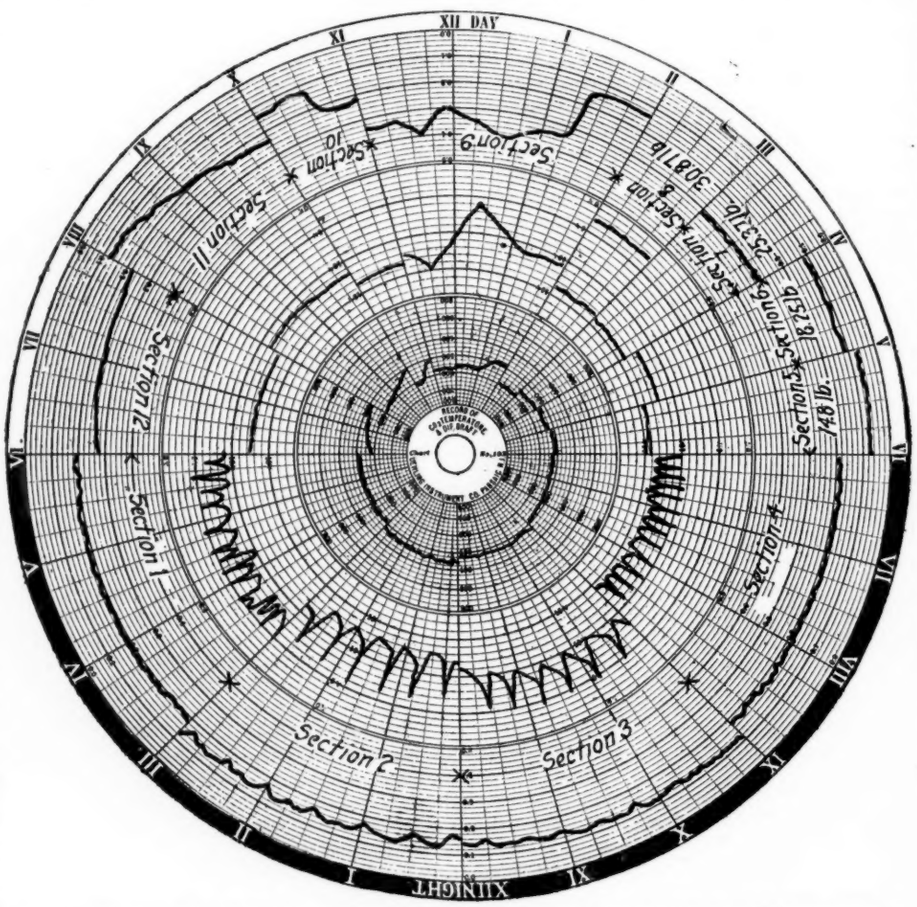


FIG. 1. CHART FROM INSTRUMENT RECORDING SIMULTANEOUSLY PERCENTAGE O CO_2, STACK TEMPERATURE AND BOILER DRAFT UNDER VARIOUS CONDITIONS

The wholesale chemical and physical method of control is based on the readings of a CO_2 meter and pyrometer inserted in the main gas flue at or near the chimney. The chemical and physical method suffers from the following deficiencies and inaccuracies: The indicated and calculated results are qualitative; the results do not represent all the heat wasted; from the CO_2 determination in the chimney one is unable to discriminate between excess air through the fire and that leaking through boiler walls, as well as that leaking into the gas flue between the boilers and the point where the sampling tube must be inserted to get the gas from all the boilers. Air entering beyond the boilers does not militate against efficiency except as it may overburden the chimney and reduce the draft below that required for efficient combustion.

The wholesale chemical and physical method has the following advantages over the mechanical method: It can be more easily and cheaply installed; the records show up the collective operation of the boilers continuously instead of only at the end of longer or shorter periods—one day at

*Abstract of a paper presented at the annual meeting of the American Society of Mechanical Engineers, December, 1918.

best; it shows up the combustion and absorption efficiency factors separately so that the proper steps to improve the efficiency of the plant can be promptly and intelligently taken; the value of its records is not affected by a vibration in ash or moisture content of coal burned, nor is the record affected by the waste of feed water or the variation in its temperature.

Both wholesale methods are equally handicapped as an aid to improve boiler efficiency, because, before one can proceed intelligently, each boiler must be diagnosed individually, and here again the CO_2 meter and pyrometer have the advantage over the water meter and coal weigher, because the former can be connected to the individual boilers with comparatively little expense and trouble, whereas it is both expensive and generally quite difficult to make connections to the water meter so that individual boilers can be served separately. The coal may or may not be readily weighed out to any of the boilers separately from the others. It is evident from this that: Either method is better than no control at all; neither method is by itself adequate to produce maximum economic results; between the two, the chemical and physical method should have the preference because it is cheaper and more readily applied, and gives more directly useful information.

To attain maximum collective boiler efficiency every boiler must be treated as an individual. To be under proper economic control both its combustion and absorption efficiencies must be under constant observation. Maximum boiler efficiency cannot be maintained without knowing what every boiler is doing all the time. To this every combustion and boiler expert will agree; but opinions will no doubt differ as to the best means for effecting this constant observation. It would appear obvious that the most direct way is the best way. Combustion is a chemical phenomenon and should therefore be most effectively controlled by chemical means. Absorption is a physical phenomenon and is best controlled by physical means. The two principal instruments of observation are the CO_2 meter, a chemical instrument, and the pyrometer, which is a physical instrument. As a necessary auxiliary the double differential draft gage is required. Boiler draft and furnace draft are essential elements in the proper control of combustion and should be observed separately.

There is no such thing as a fixed adjustment in the operation of a boiler. The rate of combustion must be changed to keep the steam pressure right, the draft must be changed to keep the rate of combustion right, and the thickness of fire must be changed to keep the efficiency of combustion (percentage of CO_2) right. As the fuel and ash bed thickens, a stronger draft is necessary to keep the required rate of combustion, and there are numerous minor variables which require changes in the draft adjustments if combustion efficiency and the required boiler capacity are to be maintained; that is, maximum CO_2 and a uniform steam pressure. To insure these results CO_2 as well as boiler and furnace draft indicators must be placed at or near the boiler front within easy view of the fireman and in close proximity to the draft-regulating wheel or lever.

Instruments Necessary for Control of Firing

Since the firemen have no control over the temperature of the escaping gases a temperature indicator is not necessary. The CO_2 meters, pyrometers and boiler draft gage should be autographic-recording. In small and moderate-sized plants the recording gages should be placed in the engine room where they are under easy observation by the operating engineer. In large plants that can afford a control engineer, other arrangements will suggest themselves.

With such an outfit on every boiler the firemen have before them at all times the information necessary for intelligent and effective control of their fires, if properly instructed how to apply this information. The steam gage tells them when to increase or decrease the rate of combustion. The boiler draft tells them whether the air supply is right for the required rate of combustion. The CO_2 indicator tells them whether the thickness of the fire is right and the furnace draft indicates the condition of the fire. The volume of air required to burn a unit weight combustible with maximum combustion efficiency varies with the kind of fuel, construction of furnace and method of stoking, but for any given set of conditions a definite volume of air will consume a definite maximum weight of fuel completely. Since the boiler draft is a fair index to the rate of the air supply it is the proper basis for regulating the rate of combustion, and the rate of fuel supply must be increased or decreased to produce maximum combustion efficiency, to which CO_2 is the index.

The three autographic records, namely, those of CO_2, temperature of the escaping gas and the boiler draft, preferably on one chart, give the engineer in charge the following information at a glance: Whether normal combustion efficiency has been maintained; and if not, the precise time when it became abnormal and how long it remained so. This enables him to inquire into the cause, with the confidence born of knowledge, and to apply the proper correction. The continuous record further reveals in hand-fired boilers how often the fires were replenished, how long the fire-doors were left open, when the fires were cleaned and how long it took to clean them. In stoker-fired boilers changes in handling the fire are similarly revealed. The temperature record shows whether the absorption efficiency has continued normal; if not, the variation may be due to necessary variations in the rate of driving, and if so this will be revealed by the record of the boiler draft, which is an index to the rate of driving. Or it may be due to a breaking-down of the baffling, which is also instantly revealed by the boiler draft. The mucking-up of the heating surface is indicated by a gradual increase in the temperature of the escaping gases. The record of the boiler draft, in addition to its contributing value to the pyrometer record, becomes in combination with the percentage of CO_2 a very good index to the rate of combustion.

Examples of Application of Information Given by Charts To Control of Firing

If these three records are all made on the same chart, they can be readily integrated by means of the polar planimeter and the heat carried to waste by the dry gases quickly calculated by the application of a formula. Autographic boiler records, like steam-engine indicator cards, are of no value unless they are regularly scrutinized and correlated and the information they give promptly and intelligently applied. If the three essential records are all on the same chart this is neither difficult nor laborious.

Fig. 1 illustrates sections of such charts showing various relations of these three records to each other. The CO_2 records shown in Secs. 1 and 2 are facsimile samples of records from a boiler of the Manning type burning No. 1 buckwheat coal. Sec. 1, made when the recorder was first installed, shows that the firing was irregular and that the coal bed was kept too thin, through which holes quickly developed. The average CO_2 was scant 8 per cent. The reason for the low CO_2 being thus clearly revealed, the proper remedy at once suggested itself. The fireman was instructed to carry a little heavier fire and watch the CO_2 indicator, with the result shown in Sec. 2, which is a sample record for the same boiler after the fireman had been instructed and had learned to be guided by the CO_2 indicator in adjusting the thickness of fire to the draft necessary to maintain the required steam pressure. So guided, he had no difficulty in keeping the CO_2 at an average of about 12 per cent. Having the three principal records on the same chart their relation to one another is readily perceived, and it will be seen at a glance that the boiler draft is about 0.08 in. higher under the conditions represented by Sec. 1 than those by Sec. 2; also the gases left the boiler at a temperature 25 deg. higher when containing 8 per cent of CO_2 than when they contained 12 per cent., which shows that absorption efficiency increases with combustion efficiency.

Records for Combustion Control of a Water-Tube Boiler Burning Bituminous Coal

Secs. 3 and 4 of Fig. 1 show records representing a water-tube boiler burning bituminous coal. Sec. 3 illustrates conditions before, and Sec. 4, after, control by aid of CO_2. A glance at the CO_2 record will show that the fires carried were too thick. The low percentage of CO_2 (about 8.75 per cent.) was due principally to air infiltration, but to a con-

siderable degree also to uneven firing producing high CO with low CO_2. Stopping up the air leaks and modifying the method of firing as illustrated by the record and using the CO_2 indicator as a guide, the fireman had no difficulty in maintaining an average of over 13 per cent of CO_2 with practically no CO.

Contrary to what was seen in Sec. 1 and 2 of the chart, both the temperature of the escaping gases and the boiler draft are higher when the conditions had been changed so as to result in the higher percentage of CO_2. This may at first seem contradictory; but a little study reveals the fact that both the boiler draft and the temperature of the escaping gases were rendered abnormally low by the flow of air (counter-draft) entering through the leaky setting. It is therefore necessary to make sure that the setting is made tight before these two factors can be relied upon as indices, respectively, of absorption efficiency and rate of combustion. Furthermore, a low stack temperature cannot be relied on as an index to absorption efficiency unless the gases contain a high percentage of CO_2.

Averages of Four Twenty-Four Hour Tests

In Sec. 5, 6, 7 and 8 of the chart are recorded the averages of four 24-hour tests of a large water-tube boiler burning bituminous coal fired by Roney stokers. The coal was burned at four different rates of combustion; namely, 16.7, 18.25, 25.3 and 30.8 lb. per sq.ft. of grate surface per hour. The CO_2 averaged 14.68, 13.05, 14.28 and 14.69 per cent.; the boiler draft was 0.08, 0.12, 0.31 and 0.61 in. of water, and the temperature of the escaping gases averaged 483, 542, 662 and 636 deg. F., respectively. The efficiency attained in these tests was respectively 81.15, 77.45, 75.28 and 76.73 per cent.

Sec. 9 of this chart illustrates the relation the three records will take to one another if the demand for steam suddenly increases and the draft is adjusted to increase the rate of combustion to meet this increased demand, but the stoker is not speeded up sufficiently to supply the coal required. The flue-gas temperature will at once go up in response to the increased rate of combustion. The CO_2 will soon begin to drop, and if there is no CO_2 indicator to show what is happening it will continue to drop until the fireman discovers that the grate is getting bare and the stoker speed must be increased. He does so, but gives it a little too much speed and the CO_2 goes above the safe limit. If he is a good fireman, he will no doubt discover that also and finally get the right adjustment. Meanwhile considerable fuel has been wasted, first by excess air, and then by incomplete combustion. With a CO_2 indicator to guide him this would not have happened.

Sec. 10 illustrates how the boiler-draft and pyrometer records will at once reveal the sudden breaking down of a section of baffling. Sec. 11 shows how the average temperature and boiler draft would be affected if the baffling disintegrated gradually, and Sec. 12 indicates how the records would be likely to change if the boiler tubes were allowed to muck up gradually. These supposititious cases are given to show how the boiler draft and exit temperatures are affected by the same cause. Neither can be correctly interpreted without the other. Within practical limits of driving the maximum percentage of CO_2 can and should be maintained, whereas both the boiler draft and the exit temperature increase with the rate of driving. The exit gas temperatures vary from the normal from four distinct causes: Rate of driving, defective baffling, dirty heating surface and air infiltration. The record of the boiler draft at once reveals the true cause; the pyrometer simply reveals the fact. Low exit-gas temperature is generally taken to indicate absorption efficiency and the CO_2 record shows whether it is or not.

Recording Instruments Must Be in Plain View

Maximum efficiency cannot be expected, and it is doubtful whether it can be attained, unless the firemen have the means of knowing all the time how well they are succeeding in maintaining it. To this end it is necessary that they have in plain view, at or near the boiler front, a CO_2 indicator, a boiler-draft and also a furnace-draft gage. With these instruments to guide them the firemen can, after being properly instructed, always maintain the combustion conditions that will produce maximum efficiency under normal conditions, and do the best that can be done should the conditions not under their control for any reason become abnormal.

In addition to the three recording instruments, an Orsat apparatus is essential for determining the maximum percentage of CO_2 that can be carried without danger of an appreciable loss because of incomplete combustion; to diagnose the boilers for air infiltration at regular intervals, or in between, if deemed necessary; and to check up the CO_2 meters when their indications give cause for suspecting their accuracy. An Orsat is by itself quite inadequate as a control for the firing operations of a boiler plant, even when supplemented by sampling tanks, which combination, although better than nothing, cannot be considered more than a makeshift.

Flow of Water Through One and One-Half Inch Pipe and Valves

Bulletin No. 1 of the Engineering Experiment Station of Purdue University, Lafayette, Ind., gives the results of tests made by Frederick W. Greve, Jr., Assistant Professor of Hydraulics, on the loss of head of water flowing through 1½-in. pipe and valves. The tests were made on 40.513 ft. of commercial 1½-in. pipe and on three standard 1½-in. brass valves—a gate valve, a globe valve and a check-valve. The experiments to determine the loss of head due to straight pipe were made with water velocities ranging from less than 0.5 ft. per sec. to about 21 ft. per sec. Those on the gate and globe valves were for five different valve openings between full open and closed.

The conclusions reached as a result of the experiments are as follows: (1) The relation of loss of head to discharge can be represented by the formula $H = MQ^n$, where H is the loss of head in feet of water, Q is the discharge in cubic feet per second and M and n are values experimentally determined. (2) The values of M and n vary with restriction of area to flow, decreasing with increase of the ratio of rise of disk to nominal diameter of pipe. (3) Weisbach's coefficients for small gate valves give values of H that are too small. (4) A gate valve causes less loss of head than a globe valve and the losses are nearly equal when the ratio of rise of disk to nominal pipe diameter is equal to 0.23.

Merchant Marine Needs Two Thousand Men

Two thousand young Americans are needed at once to train for service in the United States merchant marine, it was announced Dec. 27 by the Shipping Board. Because of the rapid delivery of cargo vessels, which are now to be manned exclusively by merchant crews, there is an unusual demand for men to be trained, which must be met within a few weeks. Of the 2000 men now wanted, 1500 are to take the places of apprentices just sent to sea from the ships of the board's Atlantic training squadron, based at Boston, and 500 for its Pacific training ship "Iris," based at San Francisco.

Volunteers are requested to apply for enrollment to any of the board's drugstore recruiting officers or to write Henry Howard, its director of recruiting service, Boston, Mass.

At a large London factory at which some Lancashire boilers were converted from coal to fuel-oil firing, the water evaporation per pound of coal, having a calorific value of 11,451 B.t.u., was 7.22, whereas when working with the pressure system of oil burning, using an oil having a calorific value of 18,750, the evaporation per pound of oil reached 14.44 lb. The quantity of water evaporated per square foot of heating surface with coal was 3.3 lb., whereas, according to A. F. Baillie in a paper read before the Manchester Association of Engineers, the quantity evaporated with oil was over 7 lb., thereby increasing the boiler rating by over 100 per cent.

New Publications

BURNING STEAM SIZES OF ANTHRACITE WITH OR WITHOUT ADMIXTURE OF SOFT COAL

This is a technical paper, issued by the United States Fuel Administration and based on an article by William T. Frey, fuel engineer. The bulletin describes what must be done to burn steam sizes of anthracite or mixtures of this coal with soft coal so as to get the most steam from the least fuel. Information is given regarding the furnace equipment required for burning various percentages of steam anthracite and soft coal, these mixtures being 20 per cent. anthracite; a second addition being 20-40 per cent. anthracite, and a third over 40 per cent. anthracite. Data are given regarding the method of mixing soft with anthracite coal, the type of grate and air space that will burn the coal satisfactorily and the method of firing the mixture.

It is stated that with a good grade of steam anthracite it is possible to obtain almost as high efficiency as with bituminous coal provided the equipment and operation of the plant are suitable, and that large savings in the cost of fuel to generate steam are effected by substituting steam sizes of anthracite for the more expensive bituminous coal, but that the best results cannot be obtained unless the changes indicated are made so that the furnace becomes efficient for the anthracite. In the summary it is pointed out that a boiler plant designed for soft coal and operating on natural draft is capable of using 20 per cent. of steam sizes of anthracite mixed with soft coal without material loss in efficiency and without change of equipment, providing sufficient grate surface is available. Still higher percentages of fine anthracite may be mixed with the bituminous, provided suitable changes are made in the furnace equipment.

Personals

L. E. MacBryde has resigned as general manager of sales of the Foster Engineering Co.

Lieut. J. B. Howell has been mustered out of the artillery service and has rejoined the Bound Brook Oil-less Bearing Co. in the position he formerly held.

Thomas Holden, for several years with the Crandall Packing Co., has joined the Atlantic Coast selling force, representing the Cassco Bar-Metallic Packing Co., with offices at 45 Second St., Hoboken, N. J.

B. R. Sausen, formerly district manager of the Chicago office of Schütte & Koerting Co., is now associated with the Star Brass Works, of Chicago, engaged in sales promotion and research work of spray cooling equipment.

Nicholas Stahl, formerly connected with the power department of the Westinghouse Electric and Manufacturing Co., has succeeded the late Martin W. Kern as general engineer of the Narragansett Electric Lighting Co., of Providence, R. I.

Morris L. Cooke, Horace K. Hathaway, Boyd Fisher, Clyde L. King, Keppele Hall and John H. Williams announce the opening of an office as consulting engineers in management, in the Finance Building, South Penn Square, Philadelphia, Penn.

Lieut. Commander Frederick L. Pryor was presented with a gold watch by the released students at the demobilization of the naval section of the Students' Army Training Corps at Stevens Institute of Technology, at Hoboken, N. J., which occurred with appropriate ceremony on Dec. 21.

Horace N. Trumbull, who has recently received his discharge from the Engineer Officers' Training School at Camp A. A. Humphreys, Va., has been appointed advertising manager of the Wellman-Seaver-Morgan Co., of Cleveland, Ohio. Before entering the service, Mr. Trumbull was advertising manager of the SKF Ball Bearing Co., of Hartford, Conn.

Walter N. Polakov, consulting engineer, announces the founding of Walter N. Polakov & Co., Inc., consultants in power production methods, industrial investigations, labor problems, scientific record systems and production accounting. With the close of hostilities a number of capable engineers formerly associated with him joined the staff of the corporation at 31 Nassau St., New York City.

F. E. Bourget, who for the last thirteen months has been handling the distribution of bituminous coal for the U. S. Fuel Administration throughout Ohio, Michigan, Indiana and the West, has resigned to identify himself with the Interstate Coal and Dock Co., as its special sales agent at Cincinnati, Ohio. Prior to his connection with the Fuel Administration Mr. Bourget had been associated with railroad and coal companies in Chicago and Cincinnati.

Frederick Pearson, for the past 15 years associated with Marshall Field & Co., as advisory engineer in the development of its various manufacturing and merchandising enterprises in Chicago and elsewhere, has opened a consulting engineer's office in the Marshall Field Annex Building, Chicago. He will continue as advisory engineer to Marshall Field & Co., in addition to other interests engaging his service. Mr. Pearson's experience has been diversified, embracing electrical, mechanical and chemical engineering.

Frederick A. Scheffler, formerly connected with the New York offices of the Babcock & Wilcox Co., has become associated with the Fuller Engineering Co., designing and consulting engineers, Allentown National Bank Building, Allentown, Penn., and will make his headquarters at their New York office, 50 Church St. The Fuller Engineering Co. is making a specialty of applying pulverized fuel to boiler furnaces for the generation of power, and Mr. Scheffler, with his lifelong experience in boiler practice, will devote his particular attention to this work.

Miscellaneous News

The Siebel Institute of Technology announces that its refrigerating engineering course will start on Jan. 15 and continue for three months. The tuition fee for that time is $250. The institute is located at 960-962 Montana St., Chicago, Ill.

Business Items

The Wellman-Seaver-Morgan Co., of Cleveland, Ohio, has opened a San Francisco office at 415-417 Rialto Building, in charge of Norman S. Ross. Business originating from California, Nevada west of the 115th meridian, lower California and the counties of Josephine, Jackson and Klamath in Oregon will receive the prompt attention of Mr. Ross.

New Construction

PROPOSED WORK

Maine, Auburn—The Water Commissioners plan to build a pumping station. W. H. Sawyer, 11 Lisbon St., Lewiston, Engr.

Conn., Bridgeport—The Baptist Christian Union, 886 Main St., will install a steam heating system in the 4 story, 80 x 102 ft. home, which it plans to build on Main and Thomas St. Total estimated cost, $100,000. E. B. Caldwell, Jr., 886 Main St., Arch.

Conn., Durham—The Merriam Manufacturing Co. plans to rebuild its factory which was destroyed by fire. Plans include the construction of a new heating plant. C. S. Palmer, 191 Church St., New Haven, Arch.

Conn., West Hartford—The town will install a steam heating system in the 2 story, 100 x 100 ft. high school, which it plans to build on South Main St. Total estimated cost, $100,000. C. S. Lane, 1631 Boulevard, Chn. of Bldg. Com.

N. Y., Buffalo—The Donner Steel Co., Inc., 475 Abbott Rd., plans to build a 1 story addition to its power house. Estimated cost, $5000.

N. Y., Herkimer—The City Commission will receive bids about March 1 for the construction of a 1 story, 40 x 60 ft. boiler house. Equipment, such as pumps, heaters, etc., will be installed in same. Estimated cost, $15,000. H. B. Sweet, Clarendon Bldg., Utica, Engr.

N. Y., New York—B. Altman & Co., 5th Ave. and 34th St., will install a steam heating system in the 6 and 9 story, 75 x 200 ft. garage and warehouse, which it plans to build on 36th and 37th St., between 2nd and 3rd Aves.; plans include the construction of a cold storage building. Total estimated cost, $250,000. F. G. Frost, 19-25 West 44th St., Arch.

N. Y., New York—The Knickerbocker Hospital will install a steam heating system in the 7 story, 150 x 200 ft. hospital which it plans to build on 130th St. and Convent Ave. Total estimated cost, $500,000. Helmle & Corbett, 190 Montague St., Brooklyn, Engr.

N. J., Ampere—The Crocker-Wheeler Co. has had plans prepared for the construction of a 1 story, 40 x 55 ft. addition to its boiler room and power house, known as plant 8-A.

N. J., Boonton—The Board of Education will install a steam heating system in the 2 story, 100 x 150 ft. school building which it plans to build on old Boonton Rd. and Lathrop Ave. Total estimated cost, $125,000. Wilson Potter, 1 Union Sq., New York City, N. Y., Engr.

N. J., West New York—The Board of Chosen Freeholders of Hudson Co., Court House, Jersey City, has had plans prepared for the construction of a 1 story, 97 x 187 ft. power house and heating and lighting plant. Percie A. Vivarttas, 110 4th St., Arch.

Fla., Jacksonville—The City Commissioners will receive bids until Jan. 10 for delivering and erecting complete, 1 surface condensing equipment with auxiliaries and equipment, having a capacity of 120,000 lb. of steam per hour in 1 unit, or 2 units, 60,000 lb. each per hour. L. E. Murphy, Engineers Bldg., Engr.

Ohio, Cleveland—The West Superior Co., c/o J. Larange, Williamson Bldg., will install a steam heating system, 6 elevators, etc., in the 17 story, 44 x 82 ft. office building which it plans to build on West 3rd St. and Superior Ave. Total estimated cost, $1,000,000. Lehman & Schmidt, 210 Electric Bldg., Engrs.

Ohio, Cleveland Heights (Warrensville P. O.)—The Board of Education will install a steam heating system in the additions which it plans to build to the schools on Noble, Fairfax and Roxboro Rds. Total estimated cost, $125,000 each. F. C. Warner, 768 Hippodrome Annex, Cleveland, Arch. and Engr.

Ohio, Massillon—The Massillon Electric & Gas Co., controlled by the Cities' Service Co., and operated by the Doherty Organization, 60 Wall St., New York City, N. Y., will rebuild its plant destroyed by an explosion last spring. Estimated cost, $30,000. J. F. O'Connor, Supt.

Ind., South Whitley—The Grip Nut Co. plans to build a power house in connection with the new plant which it plans to build. Total estimated cost, $300,000. Truman F. Miller, Mgr.

Mich., Marquette—The City Commissioners plan to issue $100,000 bonds for extensions to the electric-light system.

Mich., Saginaw—R. F. Johnson, Comr. of Light, Water and Sewers, will soon receive bids for installing auxiliary pumping unit in the West Side pumping station; also laying water mains in Porter St., from Bristol St. north, and in Niagara St., from Court to Mackinaw St. Estimated cost, $25,000. Part of the work will be done by day labor. H. H. Eymer, City Hall, Engr. Noted Dec. 10.

Ill., Cicero—The Board of Education, 5144 West 24th Pl., has had plans prepared for the construction of a 2 story, 40 x 169 ft. school and boiler room, on 57th St., between 22nd and 23rd Pl. Estimated cost, $60,000. Ashby, Ashby & Schulse, 178 West Jackson Blvd., Chicago, Arch.

Ill., Ozark—The City Council plans to construct a plant sufficiently large to light the city's main arteries and supply a limited service to the business section.

Wis., Manitowoc—William Rahrs Sons Co. plans to build a 1 story, 25 x 90 ft. addition to its boiler house. W. J. Raeuber, Arch.

Wis., Milwaukee—The Plankington Packing Co., Muskego Ave. and Canal St., is receiving bids for the construction of an addition to its engine room. C. H. Kane, Union Stock Yards, Chicago, Ill., Arch.

Wis., Waukesha—The Board of Education plans to rebuild the heating plant in the high school. Sidney Putney, Pres. Van Ryn & DeGelleke, 726 Caswell Bldg., Milwaukee, Arch.

Minn., Hibbing—The Hibbing Electric Light Co. plans to erect a new 2-story lighting plant and central building to supply the needs of the town. Estimated cost, $400,000. Charles Foster, Mgr.

Minn., Ortonville—The Ortonville Electric Power Co. plans to build a plant. Estimated cost, $75,000.

Kan., Larned—The Pawnee Power & Water Co., c/o Nathan L. Jones, owner, incorporated mith $150,000 capital, plans to build a power plant to supply light and power to 7 cities and power for pumping purposes.

Kan., Logan—The city plans an election soon to vote on a $15,000 bond issue for improvements to the electric-light and water-works plants.

S. D., Mitchell—The Trustees of the Dakota Wesleyan University will receive bids in the spring for the construction of a power house. F. H. Ellerbe, 692 Endicott Bldg., St. Paul, Minn., Arch.

Mo., St. Louis—The Christian Brothers College, 5270 Page Ave., is having plans drawn for building and equipping a power house to provide heat for college buildings and power for laundry, bakery, etc. Estimated cost, $50,000. Henry P. Hess, 4811 Cote Brilliant Ave., Engr.

Mo., St. Louis—The General Motor Corp., Boyer Campbell Bldg., Detroit, Mich., will install a heating plant in the 3-story factory which it plans to build on Natural Bridge Rd. and Union St. W. H. Kilpatrick, Flint, Mich., Engr.

Mo., St. Louis—The Union Electric Light & Power Co., 12th and Locust St., will alter its boiler house. Estimated cost, $15,000. John Hunter, Ch. Engr. Power Sta.

Ark., Clarendon—The Commonwealth Power Co. plans to erect a power plant on the river. A. Perry, Mgr.

Tex., Sherman—The Trustees of Carr-Burdette College plan to install a heating plant.

Tex., Weatherford—The city plans to rebuild the electric light plant recently damaged by fire.

Colo., Sterling—The city plans to build a heating and lighting plant.

N. Mex., Ft. Stanton—J. A. Wetmore, Supervy. Arch., Treasury Department, Washington, D. C., will soon award the contract for the installation of new engine, generator, etc., in the U. S. Public Health Sanitarium here.

Utah, Monti—The Town Council plans to build a hydro-electric plant and enlarge the present flume and distribution lines. Estimated cost, $10,000.

Ariz., Florence—The city plans to improve the water-works and lighting plants. Estimated cost, $80,000. Burns & McDowell, Interstate Bldg., Kansas City, Mo., Engrs.

Wash., Seattle—The Skinner & Eddy Corp., Railroad Ave., plans to build a 1-story, 100 x 220 ft. power house and blacksmith shop. Estimated cost, $7000.

Cal., Los Angeles—J. P. Vroman, Secy. Dept. of Pub. Wks., will receive bids until Jan. 24, for furnishing sheet steel rivets and pipe section for pipe line and penstocks for power plant No. 2 in San Francisquito Canyon. Estimated cost, $75,000. Former bids rejected. Noted Dec. 10.

P. E. I., Charlottetown—The Department of Public Works has awarded the contract for the installation of a heating system in the Military Hospital here, to the Bruce-Stewart Co., Ltd.

Ont., Cobalt—M. J. O'Brien, Ltd., Renfrew, capitalized at $20,000,000, is having surveys made at the Des Quinze water power, about 25 miles northwest of Cobalt, for a power development.

CONTRACTS AWARDED

N. Y., New York—The Board of Education, 500 Park Ave., received bids for installing heating and ventilating systems in P. S. 32, (Bronx Borough), from Daniel J. Rice, 103 Park Ave., $61,383; John C. Williams, Inc., 233 Broadway, $62,797; Gillis & Geoghegan, 537 Broadway, $66,578. C. B. J. Snyder, Municipal Bldg., Engr.

N. Y., New York—(Borough of Brooklyn)—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for installing electric lighting system in the nurses' quarters, at the Naval Hospital here, to the E. J. Electric Installation Co., 221 West 33rd St., New York City. Estimated cost, $4668.

N. Y., New York—(Borough of Brooklyn)—The Commissioner of Water Supply, Gas & Electricity, Municipal Bldg., Manhattan, received only bid for reserving and furnishing electric generating capacity, current and equipment for the use of high pressure fire service station for year 1919, from the Edison Electric Illuminating Co., 360 Pearl St., Brooklyn, $27,400. S. H. Beardsley, Municipal Bldg., Engr.

N. Y., Syracuse—The Standard Oil Co., North Beach St., has awarded the contract for the construction of a 1 story, 13 x 26 x 50 ft. pump and boiler house, to the Walsh Construction Co., 403 Herald Bldg. Estimated cost, $3500.

Penn., Philadelphia—The Pennsylvania R.R., Broad St. Station, has awarded the contract for the construction of a 1 story, 15 x 40 ft. addition to power house, to William Steel & Sons, 1600 Arch St.

Penn., Reading—The Carpenter Steel Co., River Rd. and Exeter St., has awarded the contract for the construction of a power house to the Beard Construction Co., 5th and Walnut St.

Va., Clinchfield—The International Coal Co. has awarded the contract for the construction of a coal byproducts plant to consist of boiler house, gas ovens, etc., to Ford, Bacon & Davis, 115 Broadway, New York City, N. Y.

Mich., Detroit—The Board of Fire Commissioners, Wayne and Larned St., has awarded the contract for the construction of a 2-story, 65 x 80 ft. engine house, to Max Bartholomaei & Sons Co., 466 East Warren Ave.; heating and plumbing let to M. B. O'Connor, Penobscot Bldg.

Mich., Port Huron—The city has awarded the contract for furnishing and installing two 6,000,000 gallon centrifugal pumps and two 200 h.p. motors at the water-works, to Fairbanks-Morse Co., Lafayette Blvd., Detroit. Estimated cost, $10,200. Noted Nov. 26.

Ill., Great Lakes—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for the construction of a power house here, to Hanson Bros., 127 North Dearborn St., Chicago. Estimated cost, $10,000.

Ia., Grinnell—The St. Francis Hospital, Clinton, has awarded the contract for the construction of a 2-story, 40 x 146 ft. hospital to include a 1-story, 38 x 50 ft. boiler house, to Lighter Bros., 611 Security Bldg., Cedar Rapids; heating and plumbing, to Roy Anderson, Grinnell.

Ia., Sioux City—Swift & Co., Union Stock Yards, Chicago, Ill., has awarded the contract for the construction of an addition to its cold storage building here, to F. T. Leeder, 615 5th St. Estimated cost, $10,000.

Cal., Martinez—The city has awarded the contract for the construction of an 18 x 24 ft. pump house, to M. P. Holmes, Martinez, $2800; 2 triplex pumps having a capacity of 270 gallons per minute, driven by electric motors, to Fairbanks-Morse Co., 651 Mission St., San Francisco, $6015.

THE COAL MARKET

Boston—Current quotations per gross ton f.o.b. mines are as follows.

ANTHRACITE

	Circular Current		Circular Current
Buckwheat	$3.40	Boiler	$2.65
Rice	2.90	Barley	2.40

All-rail rate to Boston is $2.86.

BITUMINOUS

Bituminous, $8 to $8.75.

Pocahontas and New River, f.o.b. Boston, $8.35 to $8.90.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* are as follows:

	Circular	Individual		Circular	Individual
Pea	$6.55	$7.30	Broken	$7.80	$8.55
Buck.	5.10	5.90	Egg	7.70	8.45
Rice	4.65	5.10	Stove	7.95	8.70
Barley	4.15	4.30	Chestnut.	8.05	8.80

BITUMINOUS

Current quotations, gross tons, based on Government prices at the mines, net ton; f.o.b., Tidewater, at the lower ports, are as follows:

	Mine Gross	F.O.B. N.Y. Gross
Central Pennsylvania (Mine run, Prepared or Slack)	$3.30	$5.45
Upper Potomac, Cumberland & Piedmont Fields:		
Run of Mine	3.08	5.23
Prepared	3.36	5.51
Slack	2.80	4.95

Quotations at the upper ports for both bituminous and anthracite are 5c. higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The rate to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	Current	One Yr. Ago	Current	One Yr. Ago
Pea	$4.80	$3.40	$6.05	$4.30
Barley	2.40	1.90	3.30	2.15
Buckwheat	3.40	2.90	4.45	3.50
Rice	2.90	2.40	3.80	3.40
Boiler	2.70	2.20	3.70	3.30

Chicago—Steam coal prices f.o.b. mines:

Illinois Coals	Southern Illinois	Northern Illinois
Prepared sizes	$2.55—2.70	$3.25—3.40
Mine-run	2.35—2.50	3.00—3.15
Screenings	2.05—2.20	2.75—2.90

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared Sizes	Slack or Screenings
Big Seam, Mary Lee, New Castle, Blue Creek, Brookdale, Milldale, Henry Ellen or Acmar	$2.45	$2.75	$2.40
Cahaba, Black Creek, Milldale, Carter and Durie seams, and Underwood seam in Etowah and Blount Counties, Jefferson seam in Marion, Walker and Winston Counties	3.45	3.75	3.10
Pratt, Brookwood, Nickel Plate, America, Jagger, Coal City, Jefferson (except in Walker, Marion and Winston Counties), Mt. Carmel seam or upper branch of Big Seam on Birmingham Mineral south of Bessemer	2.85	3.05	2.45
Helena and Harkness seams and coal mined by No. 2 Belle Helen, and Youngblood seam	2.90	3.20	2.70
Climax seam near Maylene.			

St. Louis—Prices per net ton bituminous coal f.o.b. mine today as compared with a year ago are as follows:

	Williamson and Franklin Counties, Mt. Olive and Staunton	Standard
Prepared sizes (lump, egg, nut, etc.)	$2.55@2.75	$2.40@2.70
Mine-run	2.35@2.50	2.20@2.30
Screenings	2.17@2.32	1.50@1.50

Williamson-Franklin rate to St. Louis is $1.10.

other rates p. 95.

PRICES—MATERIALS AND SUPPLIES

These are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

POWER-PLANT SUPPLIES

HOSE—

	Fire	50-Ft. Lengths
Underwriters' 2½-in.		85c. per ft.
Common, 2½-in.		25%

	Air		
	First Grade	Second Grade	Third Grade
¾-in. per ft.	$0.65	$0.40	$0.30

Steam—Discounts from List

First grade..... 15% Second grade.....25% Third grade.....33⅓%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition..... 50% Best grade..... 30%
Standard..... 40%

Note—Above discounts apply on new list issued July 1.

LEATHER BELTING—Present discounts from list in the following cities are as follows:

	Medium Grade	Heavy Grade
New York	40—5%	35%
St. Louis	30 to 50%	40%
Chicago	45%	40%
Birmingham	35%	35%
Denver	35–5%	30%

RAWHIDE LACING—40%.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam	$0.99
Asbestos for high-pressure steam	1.76
Duck and rubber for piston packing	1.10
Flax, regular	.99
Flax, waterproofed	1.21
Compressed asbestos sheet	1.10
Wire insertion asbestos sheet	1.32
Rubber sheet	.66
Rubber sheet, wire insertion	.99
Rubber sheet, duck insertion	.55
Rubber sheet, cloth insertion	.25
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.21
Asbestos wick, ½- and 1-lb. balls	.75

PIPE AND BOILER COVERING—Below are discounts and part of standard lists:

PIPE COVERING

Pipe Size	Standard List Per Lin.Ft.
1-in.	$0.27
2-in.	.36
6-in.	.80
4-in.	.60
3-in.	.45
8-in.	1.10
10-in.	1.30

BLOCKS AND SHEETS

Thickness	Price per Sq.Ft.
½-in.	$0.27
1 -in.	.30
1½-in.	.45
2 -in.	.60
2½-in.	.75
3 -in.	.90
3½-in.	1.05

85% magnesia high pressure..... Llist

For low-pressure heating and return lines { 4-ply ..... 58% off; 3-ply ..... 60% off; 2-ply ..... 62% off

GREASES—Prices are as follows in the following cities in cents per pound for barrel lots:

	Cincinnati	Pittsburgh	Chicago	St. Louis	Birmingham	Denver
Cup	7	9	5½	6.9	8½	14½
Fiber or sponge	8	10	6	13	8½	18
Transmission	7	9	6	13	9	20
Axle	4½	6	4	4.1	3½	5½
Gear	4½	9	4½	9.5	8	9
Car journal	22(gal.)	21 (gal.)	3½	4.5	5	8

COTTON WASTE—The following prices are in cents per pound:

	New York		Cleveland	Chicago
	Current	One Year Ago		
White	11.00 to 13.00	13.00	16.50	12.00 to 16.50
Colored mixed	8.50 to 12.00	12.00	13.00	11.50 to 14.00

WIPING CLOTHS—Jobbers' price per 1000 is as follows:

	13¼ x 13¼	13¼ x 20½
Cleveland	$52.00	$58.00
Chicago	48.00	50.00

LINSEED OIL—These prices are per gallon:

	New York		Cleveland		Chicago		St.
	Current	One Year Ago	Current	One Year Ago	Current	One Year Ago	Louis
Raw in barrel	$1.64	$1.20	$1.90	$1.25	$1.77	$1.18	$1.66
5-gal. cans	1.89	1.30	2.00	1.40	1.97	1.28	1.69

WHITE AND RED LEAD in 500-lb. lots sell as follows in cents per pound:

	Red				White			
	Current		1 Year Ago		Current		1 Yr. Ago	
	Dry	In Oil	Dry	In Oil	Dry and In Oil		Dry and In Oil	
100-lb. keg	14.00	14.50	12.25	12.50	14.00		12.00	
15- and 50-lb. kegs	14.25	14.75	12.50	12.75	14.25		12.25	
52½-lb. keg	14.50	15.00	12.75	13.00	14.50		12.50	
2-lb. cans	.....	.....	14.25	14.00	16.00		14.50	
1-lb. cans	.....	.....	14.25	14.50	17.00		14.50	

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ⅞ and smaller	40%	45–5%	40%
Tinned	30%	45–5%	40%

Button heads, ¾, ⅞, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.:

New York...$5.675 Cleveland...$5.15 Chicago...$5.67 Pittsburgh... 4.65

Coneheads, same sizes:

New York...$5.775 Cleveland...$5.25 Chicago...$5.77 Pittsburgh...$4.75

REFRACTORIES—Following prices are f. o. b. works, Pittsburgh:

Chrome brick	net ton	$120.00 at Chester, Penn.
Chrome cement	net ton	65.00 at Chester, Penn.
Clay brick, 1st quality fireclay	net ton	40–30 at Clearfield, Penn.
Clay brick, 2nd quality	net ton	38–48 at Clearfield, Penn.
Magnesite, dead burned	net ton	37.50 at Chewalah, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	90.00 at Chester, Penn.
Silica brick	net ton	45–55 at Mt. Union, Penn.

Standard size fire brick, 9 x 4½ x 2½ in. The second quality is $4 to $5 cheaper per 1000.

St. Louis—Fire Clay, $40 to $55.
Birmingham—Fire clay, $50; silica, $50; magnesite, $110; chrome, $165.
Chicago—Second quality, $25 per ton.
Denver—Silica, $35 per 1000.

BABBITT METAL—Warehouse prices in cents per pound:

	New York		Cleveland		Chicago	
	Current	One Year Ago	Current	One Year Ago	Current	One Year Ago
Best grade	87.00	70.00	80.00	93.00	75.00	70.00
Commercial	42.00	40.00	21.50	21.50	15.00	25.00

SWEDISH (NORWAY) IRON—The average price per 100 lb., in ton lots, is:

	Current	One Year Ago
New York	$25.50–30	$14.00
Cleveland	20.00	15.00
Chicago	19.00	13.50

In coils an advance of 50c. usually is charged.
Note—Stock very scarce generally.

POLES—Prices on Western red cedar poles:

	New York	Chicago	Denver	San Francisco
6 in. by 30 ft	$5.82	$5.17	$4.55	$5.17
7 in. by 30 ft	7.65	6.85	6.10	6.85
7 in. by 35 ft	11.10	10.00	8.95	10.00
8 in. by 35 ft	12.65	11.35	10.10	11.35
7 in. by 40 ft	12.85	11.50	10.20	11.50
8 in. by 45 ft	18.90	16.90	15.00	16.90
8 in. by 50 ft	22.65	20.30	18.00	20.30

10c. higher freight rates on account of double loads.
For plain pine poles, delivered New York, the price is as follows:

10-in. butts, 5-in. tops, length 20-30 ft	$9.00
12-in. butts, 6-in. tops, length 30-40 ft	11.50
12-in. butts, 6-in. tops, length 41-50 ft	12.50
14-in. butts, 6-in. tops, length 51-60 ft	21.00
14-in. butts, 6-in. tops, length 61-71 ft	23.50

PIPE—The following discounts are for carload lots f. o. b. Pittsburgh; basing card of Jan. 1, 1919, for steel pipe and for iron pipe:

BUTT WELD

Steel			Iron		
Inches	Black	Galvanized	Inches	Black	Galvanized
⅛, ¼, and ⅜	47%	20½%	¼ to 1¼	36%	20%
½	51%	36½%			
¾ to 3	54%	40½%			

LAP WELD

2	47%	34½%	2	29%	15%
2½ to 6	50%	37½%	2½ to 6	31%	18%

BUTT WELD, EXTRA STRONG PLAIN ENDS

⅛, ¼ and ⅜	43%	25½%	¼ to 1½	36%	21%
½	48%	35½%			
¾ to 1½	52%	39½%			

LAP WELD, EXTRA STRONG PLAIN ENDS

2	45%	33½%	2	30%	17%
2½ to 4	48%	36½%	2½ to 4	32%	20%
4½ to 6	47%	35½%	4½ to 6	31%	19%

Stock discounts in cities named are as follows:

	New York		Cleveland		Chicago	
	Black	Galvanized	Black	Galvanized	Black	Galvanized
¼ to 3 in. steel butt welded	40%	28%	41%	26%	41.1%	26.1%
3½ to 3 in. steel lap welded	36%	25%	37%	23%	37.1%	23.1%

Malleable fittings. Class B and C, from New York stock sell at list + 15%. Cast iron, standard sizes, 5% off.

BOILER TUBES—The following are the prices for carload lots, f. o. b. Pittsburgh, for delivery after Jan. 1:

Lap Welded Steel		Charcoal Iron	
3½ to 4½ in.	37	3½ to 4½ in.	15½
2¼ to 3¼ in.	27	3 to 3¼ in.	+ 2
2¼ in.	20½	2½ to 2¾ in.	+ 4½
1¾ to 2 in.	16	2 to 2¼ in.	+19½
		1¾ to 1¼ in.	+32

Standard Commercial Seamless—Cold Drawn or Hot Rolled

	Per Net Ton		Per Net Ton
1 in.	$334	1¼ in.	$214
1¼ in.	274	2 to 2½ in.	184
1½ in.	264	2¾ to 3¼ in.	174
1½ in.	214	4 in.	194
		4½ to 5 in.	214

These prices do not apply to special specifications for locomotive tubes nor to special specifications for tubes for the Navy Department, which will be subject to special negotiation.

ELECTRICAL SUPPLIES

ARMORED CABLE—

B.&S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$104.00	$138.00	$164.00	$222.00
No. 12 solid	135.00	170.00	211.00	290.00
No. 10 solid	185.00	235.00	255.00	325.00
No. 8 stranded	235.00	325.00	345.00	450.00
No. 6 stranded	370.00	472.00	625.00	.....

From the above lists discounts are:

	Net List
Less than coil lots	
Coils to 1,000 ft.	10%
1,000 ft. and over	15%

BATTERIES, DRY—Regular No. 6 size red seal, Columbia, or Ever Ready:

	Each, Net
Less than 12	$0.40
12 to 50	.38
50 to 125 (bbl.)	.35
125 (bbl.) or over	.32

CONDUITS, ELBOWS AND COUPLINGS—Following are warehouse net prices per 1000 ft. for conduit and per 100 for couplings and elbows:

	Conduit		Elbows		Couplings	
Size, In.	Black 1,000 Ft. and Over	Galvanized 1,000 Ft. and Over	Black 100 and Over	Galvanized 100 and Over	Black 100 and Over	Galvanized 100 and Over
⅛	.....	.....	$18.24	$19.38	$5.76	$6.12
¼	$76.50	$81.60	18.24	19.38	6.72	7.14
⅜	101.20	108.10	24.00	25.50	9.60	10.20
½	149.60	159.80	35.52	37.74	12.48	13.26
¾	202.40	216.20	45.45	48.15	17.17	18.19
1	242.00	258.50	60.60	64.20	21.21	22.47
1¼	325.60	347.80	111.11	117.70	28.28	29.96
1½	514.80	549.90	181.80	192.60	40.40	42.80
2	673.20	719.10	484.80	513.60	60.60	64.20
2½	837.20	892.40	1,070.60	1,134.20	80.80	85.60
3	1,013.70	1,079.10	1,237.25	1,310.75	101.00	107.00

5% cash 10 days.
From New York Warehouse—Less 5% cash.
Standard lengths rigid, 10 ft. Standard lengths flexible, ½ in., 100 ft. Standard lengths flexible, ¾ to 2 in., 50 ft.

CONDUIT NON-METALLIC, LOOM—

Size I. D., In.	Feet per Coil	List, Ft.
⅛	250	$0.05½
¼	250	.06
⅜	250	.09
½	200	.12
¾	200	.15
¾	150	.18
1	100	.25
1¼	100	.33
1½	Odd lengths	.40
2	Odd lengths	.55

Coils....55% Off..
Less coils, 40% off

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.11	T. P. to D. P. S. B.	$0.24
D. P. M. L.	.18	T. P. to D. P. T. B.	.38
T. P. M. L.	.26	T. P. S. B.	.33
D. P. S. B.	.19	T. P. D. B.	.54
D. P. D. B.	.37		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.33	$0.84	$1.68
T. P. M. L.	.48	1.20	2.40
D. P. S. B.	.42	1.05	.....
T. P. S. B.	.81	1.80	.....
D. P. D. B.	.78	2.10	.....
T. P. D. B.	1.35	3.60	.....
T. P. to D. P. D. B.	.90	2.52	.....

FLEXIBLE CORD—Price per 1000 ft. in coils of 250 ft.:

No. 18 cotton twisted	$22.00
No. 16 cotton twisted	28.40
No. 18 cotton parallel	25.00
No. 16 cotton parallel	32.00
No. 18 cotton reinforced heavy	35.00
No. 16 cotton reinforced heavy	42.00
No. 18 cotton reinforced light	30.00
No. 16 cotton reinforced light	36.00
No. 18 cotton Canvasite cord	29.00
No. 16 cotton Canvasite cord	35.00

FUSES, ENCLOSED—

250-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	$0.25
35-amp. to 60-amp.	100	.35
65-amp. to 100-amp.	50	.90
110-amp. to 200-amp.	25	2.00
225-amp. to 400-amp.	25	3.60
5-map. to 600-amp.	10	5.50

600-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	.40
35-amp. to 60-amp.	100	.60
65-amp. to 100-amp.	50	1.50
110-amp. to 200-amp.	25	2.50
225-amp. to 400-amp.	25	5.50
450-amp. to 600-amp.	10	8.00

Discount: Less 1-5th standard package 30%
1-5th to standard package 40%
Standard package 52%

FUSE PLUGS, MICA CAP—

0-30 ampere, standard package	$5.25 C
0-30 ampere, less than standard package	7.00 C

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs				Pear-Shape Bulbs			
Mazda B— Watts	Plain	Frosted	No. in Package	Mazda C— Watts	Clear	Frosted	No. in Package
10	$0.35	$0.38	100	75	$0.70	$0.75	50
15	.35	.38	100	100	1.10	1.15	24
25	.35	.38	100	150	1.65	1.70	24
40	.35	.38	100	200	2.20	2.27	24
50	.35	.38	100	300	3.25	3.35	24
60	.40	.45	100	400	4.30	4.45	12
100	.85	.92	24	500	4.70	4.85	12
				750	6.50	6.75	8
				1000	7.50	7.75	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Hubbell, porcelain No. 5406, standard package 250	$0.24
Hubbell composition No. 5467, standard package 50	.32
Benjamin swivel No. 903, standard package 250	.20
Hubbell current taps No. 5638, standard package 50	.40

RUBBER-COVERED COPPER WIRE—Per 1000 ft. in New York:

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$13.00	$16.00	$18.00	$32.00
12	16.70	18.80	22.00	36.85
10	23.52	26.10	29.10	50.60
8	31.00	36.40	40.20	70.10
6	.....	.....	62.00	.....
4	.....	.....	83.10	.....
2	.....	.....	122.40	.....
1	.....	.....	161.30	.....
0	.....	.....	189.68	.....
00	.....	.....	230.00	.....
000	.....	.....	282.40	.....
0000	.....	.....	345.50	.....

Prices per 1000 ft. for Rubber-covered Wire in Following Cities:

	Denver			St. Louis			Birmingham		
No.	Single Braid	Double Braid	Duplex	Single Braid	Double Braid	Duplex	Single Braid	Double Braid	Duplex
14	$17.00	$21.00	$39.40	$21.00	$16.00	$33.00	$13.00	$17.40	$36.80
10	25.65	28.90	64.75	27.20	31.00	69.00	21.40	24.40	42.75
8	36.45	40.25	88.45	38.00	42.00	78.00	42.35	44.35	.....
6	57.40	61.70	.....	.....	65.00	130.00	64.60	74.60	.....
4	83.40	88.70	.....	.....	93.00	.....	101.75	106.05	.....
2	126.60	132.80	.....	.....	140.00	.....	151.50	.....	.....
1	164.15	172.40	.....	.....	182.00	.....	201.00	258.50	.....
0	.....	206.80	.....	.....	242.00	.....	276.00	285.00	.....
00	.....	278.80	.....	.....	290.00	.....	317.00	330.00	.....
000	.....	341.65	.....	.....	360.00	.....	417.00	428.50	.....
0000	.....	417.05	.....	.....	435.00	.....	516.00	516.00	.....

Pittsburg—34c. base; discount 50%

SOCKETS, BRASS SHELL—

¼ In. or Pendant Cap.			¾ In. Cap		
Key, Each	Keyless, Each	Pull, Each	Key, Each	Keyless, Each	Pull, Each
$0.33	$0.30	$0.60	$0.39	$0.36	$0.66

Less 1-5th standard package +20%
1-5th to standard package +10%
Standard package −15%

WIRE, ANNUNCIATOR AND DAMPPROOF OFFICE—

No. 18 B.&S. regular spools (approx. 8 lb.)	50c. lb.
No. 18 B.&S. regular 1-lb. coils	52c. lb.

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 50c. lb., 100 lb. lots	48c. lb.
Rubber tape, ¾ in., less 100 lb., 65c. lb., 100 lb. lots	60c. lb.
Wire solder, less 100 lb. 50c. lb., 100 lb. lots	46c. lb.
Soldering paste, 2 oz. cans Nokorode	$1.20 doz.

SWITCHES, KNIFE—

TYPE "C" NOT FUSIBLE

Size, Amp.	Single Pole, Each	Double Pole, Each	Three Pole, Each	Four Pole Each
30	$0.42	$0.68	$1.02	$1.36
60	.74	1.22	1.84	2.44
100	1.50	2.50	3.76	5.00
200	2.70	4.50	6.76	9.00

TYPE "C" FUSIBLE, TOP OR BOTTOM

30	.70	1.06	1.60	2.12
60	1.18	1.80	2.70	3.60
100	2.38	3.66	5.50	7.30
200	4.40	6.75	10.14	13.50

Discounts:

Less than $10.00 list value	+ 5%
$10 to $25 list value	— 8%
$25 to $50 list value	—15%
$50 to $200 list value	—20%
$200 list value or over	—25%